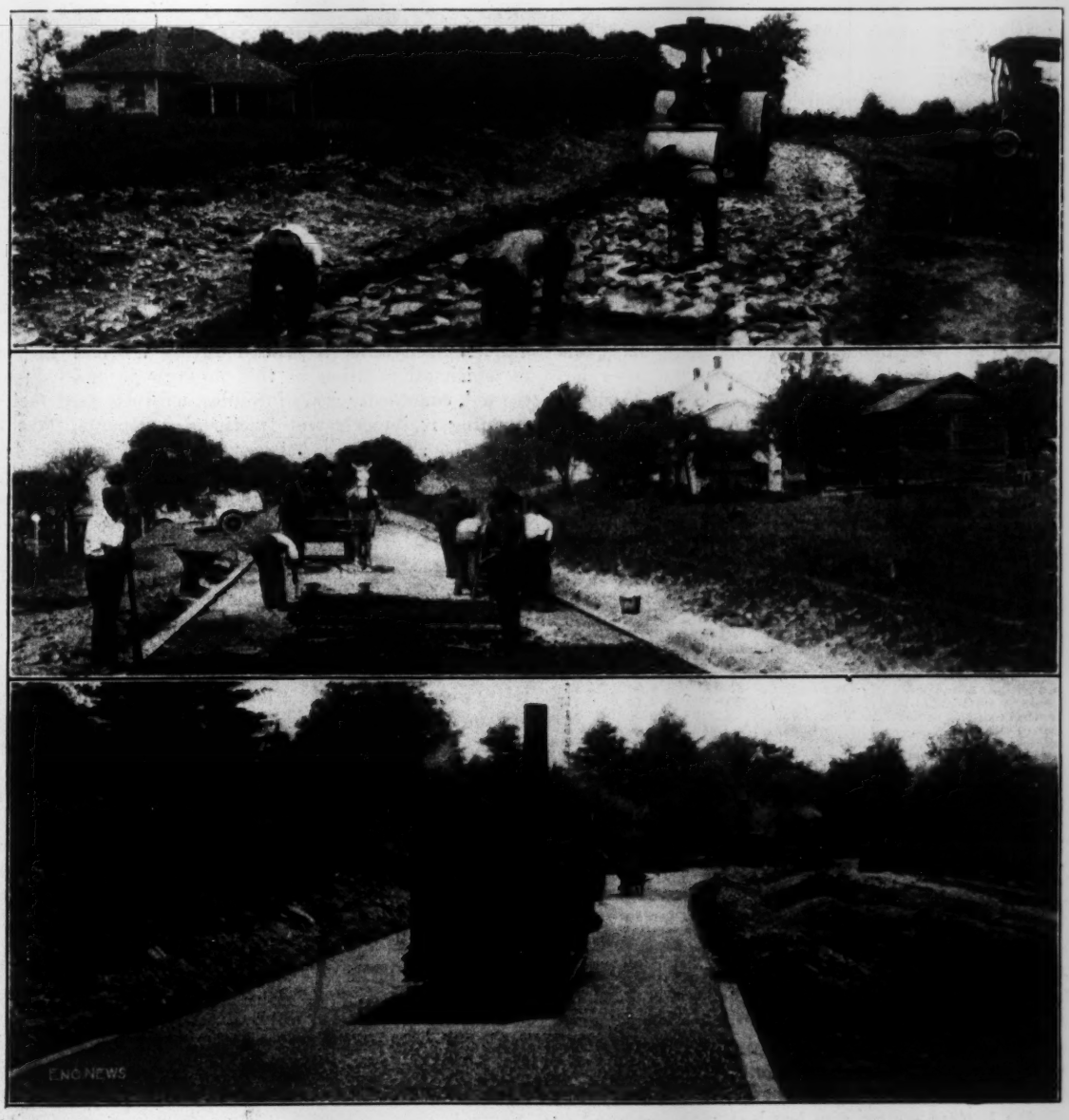
Engineering News

VOLUME 72 NOVEMBER 5, 1914 NUMBER 19

Ashokan Reservoir Roads, Built by the New York City Board of Water Supply

To replace many miles of country highways wiped out by the Ashokan Reservoir of the Catskill Water Supply of the City of New York, the city agreed to substitute about 30 miles of new highways "equal in every respect to those constructed by the State of New York in the County of Ulster." The agreement was in recognition of the inconvenience caused by having but one means of crossing the reservoir in its whole length of 12 miles.

It was further agreed that the city would undertake to maintain these roads forever. The Board of Water Supply engineers decided to pave these roads with vitrified brick, and bids were obtained from ten bidders rang-



CONSTRUCTING A BITUMINOUS MACADAM PAVEMENT; ASHOKAN RESERVOIR ROADS

ing all the way from $1,301,130 to $1,659,430. The average bids on each item are shown in Table I.

TABLE I. AVERAGE BID FOR BRICK PAVEMENT

Item	Description	Unit	Quantity	Average
1	Excavating and grading (rolling, preparation and shallow excavation)	Lin.ft. of road	207,000	$0.519
2	Excavating and grading (earth excavation not included in Item 1)	Cu.yd	45,000	0.589
3	Excavating and grading (rock excavation not included in Item 1)	Cu.yd	1,000	2.20
4	Broken stone for drainage course, etc	Cu.yd	30,000	1.69
5	Broken stone for macadam surfacing	Cu.yd	8,000	3.34
6	Concrete masonry for brick pavement foundations	Cu.yd	60,000	3.90
7	Concrete masonry for structures not included under other items	Cu.yd	6,000	7.60
8	Portland cement	Bbl.	96,000	1.96
9	Vitrified brick pavement	Sq.yd	345,000	2.22
10	Dry rubble masonry and paving	Cu.yd	4,000	2.93
11	Vitrified pipe	Lin.ft	8,000	0.402
12	Flagging	Sq.ft	1,500	0.347
13	Timber and lumber	M ft. B. M	85	58.60
14	Concrete posts with sign-boards	Post	40	19.72
15	Cast iron, wrought iron and steel	Pound	10,000	0.064
16	Repairing and building guard-rails and fences	Lin.ft	70,000	0.163
17	Painting guard-rails and fences	Lin.ft	100,000	0.058

The Board of Estimate and Apportionment was unwilling to make such a large original outlay and the decision of the type of paving was referred to a committee comprising the Chief Engineer of the Board of Estimate and Apportionment, the Chief Engineer of the Department of Finance and the Consulting Engineers of the five boroughs of the city. This committee recommended "macadam of a bituminous character," and the Board of Water Supply engineers proceeded to write specifications and obtain bids for a very high class of bituminous macadam, or perhaps more properly asphaltic-concrete pavement.

The contract for about 30 miles of this pavement and about 3 miles of waterbound macadam road was let in one job to the State Highway Construction Co., of New York City, the lowest bidder, for $659,080, probably one of the largest contracts for road construction ever let. Bids ranged from this figure to $746,115. Table II shows a tabulation of the successful bid and of the average bid.

TABLE II. BIDS FOR BITUMINOUS PAVEMENT

Item	Description	Unit	Quantity	Successful bid	Average
1	Excavating and grading (rolling preparation and shallow excavation)	Lin.ft	180,000	$0.35	$0.437
2	Excavating and grading (earth excavation not included in Item 1)	Cu.yd	45,000	0.54	0.547
3	Excavating and grading (rock excavation not included in Item 1)	Cu.yd	1,000	1.87	2.15
4	Broken stone for drainage course, maintenance, etc	Cu.yd	26,000	2.10	1.84
5	Broken stone for bottom course and waterbound macadam surfacing	Cu.yd	55,000	2.60	3.15
6	Bituminous surfacing	Sq.yd	270,000	0.76	0.727
7	Bitumen in asphalt cement	Ton	3,500	26.50	32.87
8	Concrete masonry	Cu.yd	800	8.00	8.75
9	Portland cement	Bbl.	1,100	2.00	2.02
10	Dry rubble masonry and paving	Cu.yd	4,000	3.10	3.21
11	Vitrified pipe	Lin.ft	8,000	0.27	0.292
12	Flagging	Sq.ft	1,500	0.19	0.235
13	Timber and lumber	M ft. B. M	75	45.00	57.50
14	Concrete posts with sign-boards	Post	40	12.00	19.25
15	Cast iron, wrought iron and steel	Pound	4,000	0.04	0.057
16	Repairing and building guard-rails and fences	Lin.ft	70,000	0.10	0.125
17	Painting guard-rails and fences	Lin.ft	100,000	0.05	0.05
18	Maintaining bituminous pavement	Sq.yd	270,000	0.12	0.08
19	Maintaining waterbound macadam pavement	Sq.yd	25,000	0.10	0.075

The contract was awarded July 31, 1913, and work has progressed steadily, during seasonable weather, to date.

The main part of the road surface is a well constructed water-bound macadam, with telford foundation in many places 8 in. deep. The bottom course is 6 in. of stone 1½ to 3 in. in size, placed in two 3-in. layers, rolled and filled with screenings. Before the bituminous top was placed, the bottom course was brushed with basswood or wire brooms, so that the large stones were exposed and spaces between the stones from ⅛ in. to ¼ in. deep created. This was done to give the bituminous coat a proper bond and to prevent its creeping.

The bituminous coating itself is a 2-in. course of ½-in. to 1½-in. stone mixed with 5 to 7% asphaltic cement. A description of the construction plant and an abstract of the specifications may be found in ENGINEERING NEWS, of Aug. 6, 1914, p. 300.

A Graphic Method of Determining Runoff in Storm Sewers

BY O. HUFELAND*

Among the problems of municipal engineering, none perhaps is today more obscured in the fog of theories than that of sewer design. The subject is a difficult one, and the data at hand on which to base conclusions are meager, so that it is hard to disprove theories that are obviously faulty by direct tangible demonstration of their weakness. But its study has now extended over more than 50 years, and has reached a stage where, in the hands of capable men, it has developed into a true science, so that the continuation of old errors is no longer excusable. That such errors are continued can be attributed to but two reasons: one, ignorance of this progress, and the other lack of courage to admit old errors. Both are unfortunate for the client of the engineer laboring under these shortcomings.

In the scientific periodicals and the publications of our engineering societies, many papers and the resultant discussions have been printed during the last 10 years in which all mention of this progress is omitted; and the old, concededly weak formulas, with assumed factors, startling reciprocals and fractional exponents, have become the shuttlecock between writers of a little book learning and a conspicuous lack of experience. "Capillary action for small depths," "the inertia of the water" on the surface, "wetted film" are illustrative expressions, instead of a plain statement that the delay in runoff is due to unevenness of surface, and a primary absorption and evaporation at the beginning of a storm. Add to the preceding a "cubic parabola" and you have the mystery complete.

These methods have been discredited in other countries, where for at least a half dozen years much simpler and more correct methods have been exclusively used by the best engineers without, so far as I know, getting into print here.

The new method discards many of the fetishes of the old school, and compels the engineer who uses it to have some practical knowledge of the subject, instead of reading his "computations" from a ready-made diagram prepared under some other man's theory, which very rarely fits the conditions which the new work is intended for.

A brief history of the new way may help to give it standing. As early as 1887 an Italian engineer in studies for the sewers of Milan pointed out the inadequacies of the old methods. In 1894, Prof. Frühling, one of the most eminent authorities on sewerage, pointed out the absurdities of the exponential formula for determining the correct quantity of water flowing through sewers

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as the result of a given rainstorm. Between that date and the present time the following have added their approval of the opinions above expressed, and have provided a new graphic method exquisitely simple and elastic enough to adjust itself to any combination of conditions for which sewer sizes must be found: Knauff, 1894, 1896, 1911; Forbat-Fisher, 1901; Hecker, 1910; Schulze, 1902; Frühling, 1904; Heyd, 1905; Kayser, 1905; Vicari, 1907, 1908, 1911; Range, 1908, 1912; Nehring, 1908; Weyrauch, 1912; Kalbfuss, 1912; in fact, practically all the European writers of this period with one exception, and that is F. Grimm, in the Gesundheits Ingenieur, 1911, who makes a plea for the old methods by saying that five smaller cities have used them in the past and have not yet had trouble, but does not deny that the new methods are better.

One of the underlying distinctions of the new method is an acceptance of the postulate "that a definite intensity of rainfall during a definite period must result in a definite maximum of runoff, but that this maximum does not necessarily occur when the runoff from the whole drainage area reaches a given point in a collecting sewer." A "definite intensity" means, of course, a rate of precipitation which is substantially uniform during the "period," and not an accumulation of rainfall at various intensities during an assumed period. Uniform intensities of 1 in. per hr. and over rarely have a duration exceeding 20 minutes in the neighborhood of New York.

In a sewer system for an area in which the period of maximum intensity of rainfall is less than the time required for the maximum runoff to reach the outlet, the use of a constant formula "is wrong, gives senseless results and is not justifiable, simply because certain systems built upon such computations have not yet failed." (Prof. Weyrauch.)

To say that the eight or ten best known formulas are based on error may seem presumptuous; but the application of a constant to "area" instead of "time" seems to justify such a statement. Mr. Kuichling's is the only departure from such a theory, and for this and the insistence on the use of the actual uniform intensities of rainfall, instead of misleading accumulated quantities over long periods, he deserves the credit not only for correct analysis, but for his courage in dissenting from an old and universally accepted error.

The authors mentioned above describe a number of methods, but the one that has found most favor is a modified form of that given by Vicari and printed in the 1909 and 1912 editions of "Hütte," Vol. III, the well known German engineering handbook, from which I will make a free translation of the essential portions, retaining the metrical units, which can easily be transformed into terms current here.

Vicari's Method of Computing Runoff

If q_r equals the quantity of water in liters per second falling on a hectare, and E equals the number of hectares in the area under consideration, then the total runoff in liters per second, Q_r, is not $q_r E$, but $Q_r = \varphi q_r E$. In this, φ is the percentage of rainfall that is not evaporated or absorbed, and usually is called the coefficient of imperviousness.

The following values may be taken for φ for different surfaces:

Roof surfaces	0.8 to 0.9
Waterproof pavement	0.7 to 0.9
Common pavement	0.4 to 0.7
Macadam pavement	0.4 to 0.6
Park walks	0.2 to 0.4
Unpaved surface	0.1 to 0.2
Parks and gardens	0.0 to 0.1

As a drainage area generally consists of an aggregation of smaller areas of different degrees of imperviousness, the coefficient for the total district would be

$$\varphi = \varphi_1 p_1 + \varphi_2 p_2 + \varphi_3 p_3 + \ldots$$

in which p_1, p_2, p_3, etc., are fractions of the area having a different surface, and therefore a different coefficient φ_1, φ_2, φ_3, *etc.*

Water Reaching Sewer—At the beginning of a rain storm, only that area nearest a given point in a sewer furnishes water to it. As the storm continues, the areas farther away gradually contribute until, if the storm lasts long enough, water from the entire district will reach the given point. From this it appears that the duration as well as the rate of rainfall affects the discharge of a sewer. If it stops raining before water from the remotest part of the district drained reaches the part of the sewer under consideration, then only a fraction of the total runoff in liters per second, $Q_r = \varphi q_r E$, will be carried by the sewer at this point. This fraction was designated by a uniform retardization coefficient by Bürkli-Zeigler, Mank, Brix, Büsing and others; but this method has justly been discarded by Frühling because it failed to regard the size and shape of the area drained, as well as the velocity of flow in the sewers computed.

Method of Computing Runoff—The delayed runoff from the outer areas causes a reduction in the discharge at any point in a sewer, which may be determined by making a flow diagram for that point.

This diagram is developed by plotting the duration of rainfall as asbscissas and the resulting amount of runoff as ordinates of a right-angle system of coördinates.

Flow Diagram—Such a diagram is shown in Fig. 1 and may be obtained as follows: Assuming the distance from the remotest portion of a sewer district to a point in the sewer to be l and the velocity of runoff in the sewer to be v (this assumes that the sewer drains the remote part), then the time, t_l, that it will take water falling at the edge of the district to reach this point will be

$$t_l = \frac{l}{v}$$

At the end of this time, the entire drainage area E_l hectares is supplying the total discharge $Q_l = \varphi q_r E_l$ liters per sec., providing the storm continues.

In the diagram shown, the point B is located by taking t_l as the abscissa and Q_l as the ordinate. To obtain Q_l, it is necessary to find the rainfall in liters per sec. per hectare, q_r, for the storm for which the system is to be designed. This value of q_r multiplied by the number of hectares E_l and this result multiplied by the coefficient of imperviousness for the area considered gives Q_l.

Under the admissable assumption that the runoff to the sewers is uniform from each contributing strip and that t_r indicates the duration of the storm considered, the runoff Q_t at any time t is represented by the ordinate to the lines A,B,D,C.

It is evident from the diagram that when t (any time

at which the runoff is desired) is less than t_l, the time required for water falling at the edge of the district to reach the sewer junction, that the amount of water flowing in the sewer is only a portion of the quantity which will be flowing at the end of the time t_l. This ratio may be expressed as follows:

$$Q_t = \frac{t}{t_l} Q_l.$$

In this, Q_t equals the runoff in liters per sec. at the time t.

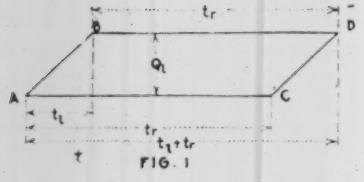

FIG. 1

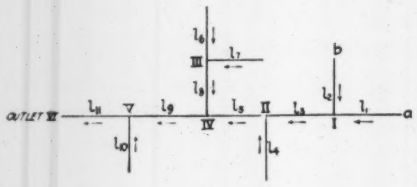

FIG. 2

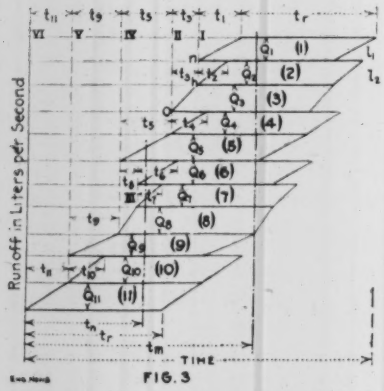

FIG. 3

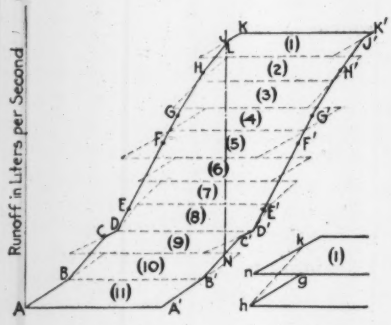

FIG. 4

FIG. 5

If t is greater than t_l and less than t_r, then $Q_t = Q_l$. If t is greater than t_r but less than $t_r + t_l$, then

$$Q_t = \frac{t_l + t_r - t}{t_l} Q_l;$$

and, if t is greater than $t_r + t_l$, then $Q_t = 0$.

It takes the same time, t_l, for water falling at the remote portion of the district, at the beginning of the storm, to reach the junctions in question as it does for water falling at the end of the storm to reach this point; therefore, since the duration of the storm, t_r, is a constant and t_l influences the discharge at the beginning and end of the storm by the same amount, AB and CD are parallel.

SUMMARY OF PRECEDING—In order to make the foregoing nomenclature and results more clear for practical use, they may be summarized as follows:

q_r = Quantity of water in liters per sec. falling on one hectare.

E = Number of hectares in area considered.

φ = Coefficient of imperviousness.

Q_r = Quantity of water in liters per sec. running off from E hectares.

l = Length of stretch of area considered.

v = Velocity of flow in sewer.

$t_l = \frac{l}{v}$ = Time required for water falling on remote part of drainage area to reach sewer junction,

t_r = Duration of rainfall.

METHOD OF COMBINING FLOW DIAGRAMS—The preceding has shown how the flow diagram for a single area drained by a lateral is obtained. For a system of drainage areas, the flow diagrams for the individual areas are combined according to the following rules:

1. The flow diagrams for areas which discharge to the same sewer junction have the same initial abscissa.
2. The flow diagram for the area between two junctions has an origin of abscissa to the left of the diagram above it by a distance

$$t_l = \frac{l}{v}$$

where l = the length of the drainage area and v = velocity in the sewer draining that length.

3. In plotting the diagrams, begin with the area at the extreme edge of the district and continue downward step by step.

GENERAL CASE—The foregoing may be made more clear by considering a general case. The combined diagrams for the system of laterals shown in Fig. 2 are shown in Fig. 3 and obtained as follows:

In Fig. 3 (1) represents the flow diagram for the area drained by l_1, Fig. 2; t_1 is the time required for water falling at a to reach I; Q_1 is the total runoff in liters per second from the area drained by l_1, all of which does not reach I until the end of time t_1. Q_1 will be the amount of discharge for which the lateral l_1 must be designed. (2) represents the flow diagram for l_2, Fig. 2, and since l_1 and l_2 flow into the same junction I, they have the same initial abscissa, t_2 is the time required for water falling at b to reach I and

$$t_2 = \frac{l_2}{v_2}$$

Q_2 is the total runoff in liters per sec. from the area drained by l_2, and the quantity reaches I at the end of the time t_2. The total quantity of water per sec. reaching I at the end of any time t is the sum of the ordinates of the diagrams (1) and (2) at the end of that time, t being measured to the right from h.

For (3), the time t_3 is laid off to the left of the origin of (1) and (2) as the area drained by l_3 lies between junctions I and II; t_3 is the time required for water falling at I to reach II,

$$t_3 = \frac{l_3}{v_3}$$

and it will be at the end of this time that water from l_1 and l_2 reaches II. Q_3 is the total runoff from the area drained by l_3. To find the quantity of water in liters per sec. flowing in l_3 at II at any time t, with O as an origin and t as abscissa, sum up the ordinates at the end of time t of all the preceding diagrams. In this case, the maximum amount of discharge that l_3 would be designed for, would be $Q_1 + Q_2 + Q_3$. The diagram is continued in a similar manner for the remainder of the system.

The sum of the abscissas $t_1 + t_3 + t_5 + t_9 + t_{11}$ is the total time required for water falling at a to reach VI. These correspond to l_1, l_3, l_5, l_9 and l_{11}, Fig. 2, which form the main sewer. The laterals l_2, l_4, l_6, l_7, l_8 and l_{10}

discharging into it do not affect this time, but do add to the quantity, as shown by the ordinates in the diagram.

The sum of these ordinates indicates the total quantity in liters per second that flows through the sewers at any required time. For instance, the amount of water passing through the collecting point *VI* in the time t_n (see Fig. 3) consists of the sum of the ordinates at the end of this time for all the preceding diagrams ($Q_{11} + Q_{10} + Q_9 + Q_8 +$ a portion of Q_7, Q_6 and Q_5, while (1), (2), (3) and (4) furnish no water at this time. For the time t_m laterals l_8 to l_1 furnish water to *VI*, the quantities from l_{11}, l_{10} and l_9 having already passed *VI*.

Maximum Discharge—The maximum quantity of water flowing through *VI* is indicated by the longest ordinate in the combined diagram, Fig. 3, the location of this ordinate also showing the time at which this occurs; or, in other words, the maximum quantity of water that is discharged at *VI* (and which l_{11} should be designed to carry) would be at the end of the time where the sum of the ordinates of the diagrams (11) to (1) is a maximum.

Method of Revising Combined Diagram—In order to simplify the finding of the required ordinates, a method of adjusting the combined diagram has been devised, shown in Fig. 4. It consists in turning down the projecting ends of the single diagrams on the left and turning up those on the right into a compact figure from which the ordinates may be easily scaled. This is accomplished as follows: The area (1), Fig. 5, protrudes to the left of (2) by an amount *nkg*. Draw the line *kk* in such a manner that its vertical distance from *hg* at any point is equal to the distance of *nk* above *ng* at the same vertical; *hk* is therefore a part of the corrected diagram. By locating points as above, the line *ABCD*, etc., is found, and by a similar method *A'B'C'D'*, etc., may be obtained. Since t_r is constant *A'B'C'D'*, etc., will be parallel to *ABCD*, etc. It would therefore be only necessary to plot and correct one of the ends of the diagram; and by moving the line so found horizontally for the distance t_r, representing the time of the storm under consideration, the diagram may be completed.

Any ordinate of the continuous diagram, Fig. 4, will equal the sum of the ordinates of the individual diagrams, Fig. 3, at the same vertical. The longest ordinate within the diagram, Fig. 4, is at *LN*, which will be the quantity of water in liters per second for which the outlet l_{11} at *VI* must be designed. Lateral l_9 would also carry the same amount.

The quantities of storm water for which the system would be designed are therefore as follows:

Lateral	Quantity of water in liters per sec.
l_1	Q_1
l_2	Q_2
l_3	$Q_1 + Q_2 + Q_3$
l_4	Q_4
l_5	$Q_1 + Q_2 + Q_3 + Q_4 + Q_5$
l_6	Q_6
l_7	Q_7
l_8	$Q_6 + Q_7 + Q_8$
l_9	LN
l_{10}	Q_{10}
l_{11}	LN

Caution and Final Comment

In order to avoid misunderstanding, the present author would point out that the method above described permits the use of any formula for fixing the percentage of water that reaches the sewers, as well as any formula for determining the velocity of flow in them. It is sufficiently elastic to fit any condition, and will permit the engineer to make use of information furnished by a study of the area to be drained.

But its most striking advantage is the clear demonstration that the application of a constant to the "area" is wrong in principle. By most of the old methods the total area drained by all the sewers, l_1 to l_{11}, would have been used as a base of computation, resulting theoretically in a sewer gradually increasing in the size to the outlet. The new method conclusively shows that such a theory is faulty, and that l_{11} carries no more water at any time than l_9, notwithstanding the increased area drained by l_{10} and l_{11}, the flow from the latter having passed out before the maximum from the whole area reaches the outlet.

The Illuminating Power of Kerosene Oil is reported on by William Kunerth, Assistant Professor of Physics and Illuminating Engineering, Iowa State College of Agriculture, in a bulletin of the Iowa Engineering Experiment Station. The tests were to determine the quality of kerosene oil used in the state and relations between the illuminating power and physical properties, so that the usefulness of an oil could be judged without the long, tedious tests of burning. Some 61 samples in all were tried.

The oils were burned in a small metal lamp with a No. 2 flat-wick burner and glass chimney. The wicks were all of the same weight and ⅞ in. wide. About one-half pint of oil was used in each test to keep temperature effects similar. Before testing a sample, a new wick was burned in it for three hours to reproduce service conditions. A new wick was used for every sample of oil. The amount of oil burned was determined by balance and stop watch. Candlepower was measured on a 2-in. photometer. Several determinations were made with flame at different heights and the curve of candlepower and illuminating power plotted. Because of great influence of atmospheric conditions, it was necessary to test a sample of one oil selected as standard whenever unknown specimens were tested. The term "illuminating power" used below is used to cover the number of candlepower-hours per gallon of oil.

A greater flux of light was obtained from the cheaper oils, the average cost of 100 candlepower-hours running from 0.89c. for a 10c. oil to $1.97 for a 27c. oil. Higher-priced oils were from Eastern fields and had a lesser density. The heavier oils fogged the chimney more and the lighter oils less, the low illuminating power of the latter being somewhat compensated for by lessening the labor or expense of cleaning. Oils of lowest illuminating power charred the wicks most. No difference in the unpleasantness and quantity of odor given out by the different oils could be detected. Contrary to the usual statements, the lighter oils are not as desirable as the heavier ones. The average density of oils whose illuminating power was less than 1100 cp.-hr. per gal. was 0.801 gram per c.c., while the average density of oils with an illuminating power above that figure was 0.818 gram. The oils of greater density also had a greater relative carbon content. All the oils had a flash point above 100° F. The oils having high illuminating power also had a high flash point, and vice versa, those below 1100 cp.-hr. showing 110° average, while those above had 116° average. The relation between illuminating power and burning point was similar, but not as well marked. A range of over 50% was found in viscosity of the samples and the relation of viscosity to illuminating power was not very definite, although in general it appeared that the oils of high illuminating power were comparatively the more viscous. An increase in surface tension was in general accompanied by an increase in illuminating power. Seven of the samples selected had been colored red and were light oils with low illuminating power. Therefore, one of the heavier oils was colored with alkanet root, whereupon its illuminating power was decreased 2%. A sample exposed to daylight and sunlight for six weeks showed a decrease of 15% in illuminating power.

The cost of kerosene illumination from the average of the samples tested was found to be 19c. per 1000 cp.-hr. This was found to be the same as the cost of electric illumination with tungsten lamps in Ames, the lamps having an efficiency of 1.25 watts per candlepower and current selling at 11.7c. per kw.-hr.

Development of Sand and Gravel Deposits

By W. H. Wilms*

SYNOPSIS—The preliminary steps in developing sand and gravel deposits are discussed in detail. The type of steam-shovel, the essential points in stripping overburden by hydraulicking, the layout, grades and construction features of railway tracks are described from the point of view of one having several years' experience in this work. Other articles will follow, describing and discussing methods of operating sand and gravel plants.

With the remarkable growth of the sand and gravel industry during the past five years has come an increased demand for a better grade of material. New standards of quality have been set up which the producer must be prepared to meet if he is to continue in business. For some plants now operating this means better preparation of material; for others it means the abandonment of the inferior deposits now being worked; for no amount of preparation will ever make a first-class product from poor and defective material.

The next five years will undoubtedly witness another large increase in the growth of this industry. New deposits will be opened up, new plants put into operation and many now engaged in other lines of industry will turn toward this. Mistakes, of course, will be made, for the industry is beset with all manner of snares and pitfalls for the inexperienced.

With the idea of giving an outline of the essential requirements in the development of sand and gravel deposits and the present methods of design and operation of screening and washing plants this and a subsequent paper have been prepared. To engineers interested in concrete materials the writer hopes they will prove of special interest and value.

Examination of Deposit

Too much emphasis cannot be laid upon the importance of a thorough examination and test of a deposit under consideration for development. Only too often a hasty and superficial examination is the rule and not the exception.

Test Wells—Due to extreme variations in the character of bank gravel within comparatively short distances, a sufficient number of test wells should be sunk to make absolutely certain the nature and character of the deposit. Open wells should be sunk and not mere auger holes, for only by an actual examination of the material in place can a correct and accurate estimate be formed as to the character and value of the deposit. A few hundred dollars might better be dropped here than several thousand afterward.

The test wells should be carried down to the bottom of the deposit, or as far down as it is practicable to develop the property. From each well the following data should be obtained: the thickness and character of the overburden; the thickness and character of each stratum of sand and gravel. The thickness of the various strata should be measured on all four sides of the well. The dip or angle of inclination of each stratum should also be noted. The elevation of the bottom of each stratum referred to a common datum should also be obtained with a view to connecting it, if possible, with similar strata in the other wells.

Analysis of Material—The size and graduation of the material in each stratum should be obtained by taking the entire amount excavated and screening it through a series of sieves. The character or composition of this material should also be obtained, i.e., the percentage of crystalline, granular, slaty and compact rocks and their hardness. The amount and character of the impurities should also be ascertained. The composition, average size and percentage by weight of all stone over 2 in. should also be obtained; this will afford a criterion as to the amount of crushing necessary.

Quantity—The elevation of the bottom of the deposit in each test well should be obtained and referred to a common datum. By connecting up these elevations a comparatively accurate profile can be made of the bottom of the entire deposit—very useful information, if it is finally decided that the deposit is worth developing.

Development of Deposit

Considerations of capacity, depth of deposit, presence of water, etc., largely determine, of course, the method of excavation. Where conditions, however, will permit of the development and working with a steam-shovel this method of excavation has many advantages worthy of consideration. It often happens that where dry deposits have been opened up and worked over with an orange-peel, clam-shell, or drag-line bucket, or any excavator of this class, the pit is left in very bad condition when increased capacity demands a change to steam-shovel operation.

Often steep grades out of the pit and other conditions make this change to steam-shovel operation under the above conditions an expensive proposition, if not absolutely prohibitive. This question of a possible future increase in capacity and a change to steam-shovel operation should be kept in mind in considering the type of machine for original development.

Steam-Shovel Development—In considering development with a steam-shovel, where a working face or bank has to be opened up, two methods of attack are possible. The working face may be obtained by the side-cut method or by a through cut. In the former method the face is obtained by making a series of comparatively shallow cuts until the full face is finally obtained. While this method is largely used on railway and construction work where the requirements of large output and the necessity of often working several shovels on the same cut demand this method, it should be adopted with caution in opening up a gravel deposit.

Due to the fact that practically all gravel deposits are highly stratified, a uniform run of material in many cases is practically impossible where the face is being developed by this method of side cutting. Another disadvantage of

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side cutting is the necessity of using a shovel that can dig at least from 5 to 8 ft. below the loading track. This means either an A-frame or railroad shovel with an operating crew of three men, or an excessive and impracticable amount of blocking for a revolving shovel.

Unless the deposit presents a natural face or bank from which to begin operations it is generally advisable to make a through cut. In so doing the full working face is quickly attained, assuring a uniform run of material and a low initial stripping charge per cubic yard of material.

Of course there are some disadvantages attending the use of this method of attack such as cramped quarters, the "spotting" of but one car at a time to the shovel, with consequent reduction in the capacity of the machine; but the advantages generally far outweigh the disadvantages.

TYPE OF STEAM-SHOVEL—The type of shovel to use largely depends, of course, upon the capacity required. Where the requirements of capacity come within the limits of a revolving, one-man shovel, however, there is no question but what this is the type of shovel to use. There are many such shovels operating in gravel pits excavating from 300 to as high as 900 cu.yd. of material per 10-hr. day, with an operating crew of one man; and this man does his own firing.

In operating an A-frame or railroad shovel it is necessary, of course, to bring the shovel back to the beginning for each successive cut. Unless a track is kept built up behind the shovel a delay of several days is necessary to "cut out" the shovel, bring it back, shift the running track and "cut in" again. Often this delay must be suffered at the busiest time of the season. Delays to a busy plant are costly and anything that will reduce them is certainly worth consideration.

STRIPPING DEPOSITS

The problem of the removal of the overburden or stripping should be studied in conjunction with development; for upon the solution of one largely depends the solution of the other. The subject is a large one and demands more space than can be allotted here for even a brief analysis.

HYDRAULICKING—I will, therefore, confine my remarks to a method of stripping that has been found to be the most effective and economical where the conditions are favorable for it. This is removal or stripping by water or hydraulicking. It has been my experience, that where conditions permit of this method, it is accomplished at a cost far below that of any other. I have removed many hundreds of cubic yards of stripping by hydraulicking for as low as 6c. per cu.yd.

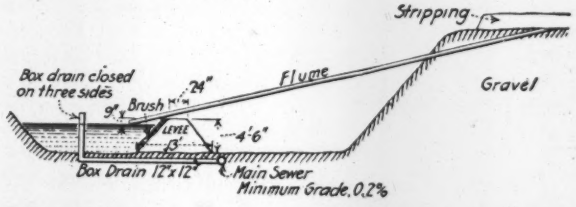


FIG. 1. SKETCH OF LAYOUT FOR HYDRAULIC STRIPPING

The conditions necessary for hydraulicking are a plentiful supply of water, a disposition for the overburden, drainage for the waste water and ample grades for the flumes or sluices carrying the material. After a gravel bank is opened up, the overburden may be deposited directly on the floor or bottom of the pit provided there is means of drainage to carry off the waste water. Small levees are built up of gravel backed up with brush to retain the material and prevent overflowing. Sewer pipe or box drains are placed in the center of the pond thus formed, their tops flush with the pond level (Fig. 1).

Another method of retaining the material where disposition is made in the bottom of the pit is by means of sheerboards. This method, known as sheerboard construction, is largely used in the building of dams and fills by hydraulicking. Under many conditions it is cheaper and more effective than the construction of earth or gravel levees. In this method the material is retained by two or more small bulkheads or sheerboards made of two 1x12-in. boards, nailed to 2x4-in. stakes about 7 ft. long. The 2x4's are pointed at one end and driven into the ground on about 4-ft. centers. (See Fig. 2.)

After the material is carried up to the top of the first

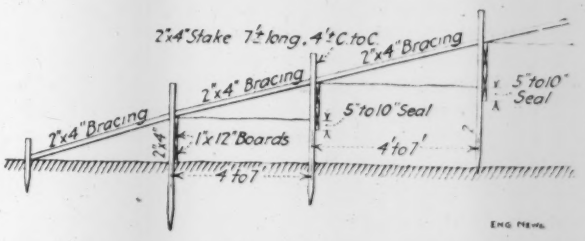


FIG. 2. SHEERBOARD METHOD OF RETAINING MATERIAL

row of sheerboards, a second row is built from 4 to 7 ft. back of the first. The bottom of this top sheerboard is placed from 5 to 10 in. below the top of the lower bulkhead to prevent the material from bulging and flowing out between the two bulkheads. The amount of seal necessary depends upon the nature of the material being handled. In ordinary loam 6 in. has proven effective while in fine clay or sandy loam 10 in. is often necessary. As many sheerboards are built in the above manner as is necessary to take care of the stripping over a given area. In this method the water is taken off through spillways which lead to the pipe drain or to some natural drainage course.

If no natural outlet for drainage exists it may be necessary to install a centrifugal pump to take care of this water. Where a small yardage only is required per day, it is often possible to let seepage and evaporation take care of this water, provided there is no natural outlet. However, drainage is always to be preferred and generally is a necessity. Where seepage and evaporation are depended upon to any extent, the bottom is soon silted and clogged up, resulting in the overflow of the levees and break-throughs. Where disposition is made in the bottom of the pit, the fall necessary for the flumes from the top of the gravel bank to the waste pond is generally ample.

The character of the overburden must be such as to be easily handled with water. Clay is generally a very difficult material to handle, requiring more water, greater pressure, and greater flume grades to handle than ordinary loam or dirt. The amount and size of rocks, if any, also affect the efficiency of this method.

QUANTITY OF WATER REQUIRED—No rules can be laid down for the quantity of water required per cubic yard

of material removed, pressure of water necessary and the grade of flumes required; these factors depend entirely upon the nature and character of the material to be handled. There is sometimes found a fine, heavy, dead sand on top of the gravel deposit which requires nearly twice the amount of water, pressure and flume grades to carry it than the soil above.

The quantity of water is generally more important than the pressure. Comparatively light grades can be used for the flumes if a sufficient quantity of water is present to effect complete suspension. As heavy grades as possible, however, should be used, for the greater the grade the less the dirt has to be carried in suspension, with a consequent increase in the carrying capacity of the water.

An overburden composed of soft loam with no rocks or boulders and no dead sand to contend with has been removed with flume grades of 8% and a delivery of 1500 gal. of water per cu.yd. of material removed. A pressure of 75 lb. per sq.in. was used.

Due to the comparatively shallow working face and the consequent frequent changing of pipe connections, and flumes, hydraulicking, when applied to gravel stripping, does not show the same degree of efficiency and economy that can be obtained under the more favorable conditions of a high working face. Even under such adverse conditions, however, the economy that can be obtained by this method where the other conditions are favorable is very great.

Layout of Tracks

The track layout should permit of easy and flexible switching operations, otherwise costly and vexatious delays and interferences in switching are very likely to result. Whenever it is possible the main track serving the plant should have switching connections with the main track of the railway at both ends. Empty and loaded cars can then be switched without interfering with the operation of the plant. Where conditions make such an arrangement impracticable, a run-around track should be built so as to permit of switching operations while cars are being loaded at the bins (Fig. 3).

Switching Tracks—Switching tracks having excessive curvature and grades are a constant source of delay due to derailments and the inability of the locomotive to "pull" the load tracks without excessive switching. While conditions more or less fix the alignment and grades that must be used, there is often considerable latitude in this direction, of which full advantage should be taken. A curve of 10° should be considered a maximum for switching tracks for road engines, while 14° to 16° is about the maximum for switching engines. Grades for the outbound load tracks should, of course, be kept as low as possible—3% being considered about the maximum here.

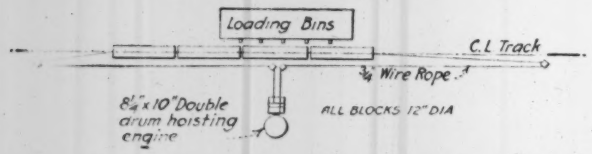


Fig. 3. Sketch of Track Layout at Loading Bin

Rails—I have learned by costly experience that there is no economy in laying down tracks with light 60-lb. rails. The extremely severe and heavy service that engines have to perform about a gravel pit demands a good track built of at least 70-lb. rails; an 80-lb. rail is better and is considered by the writer the only rail to use in tracks over which switching operations are performed. Dead-end empty storage tracks over which engines very seldom go is another matter, and here good 60-lb. relayer rails will generally answer the purpose.

Loading and Storage Tracks—Wherever conditions permit, the empty-car storage tracks above the plant and the load-storage tracks below should be on a continuous down grade, so as to permit "spotting" of the cars to the plant by gravity. Straight, empty, storage tracks should have a grade of at least 1% and better 1½%. The short stretch of track in front of the plant at the loading chutes should have at least a 2% grade. The grade of the load-storage tracks should be at least 1%.

If curvature occurs on any of these tracks, due allowance should be made for it in establishing the grades. If the handling of cars by gravity is going to be a success and not a source of constant delay and trouble, the tracks must have sufficient grades and be so surfaced and aligned that the cars will start anywhere with one or two pumps of the car pincher.

Where the capacity of a plant is 20 cars or more per day, it often pays to install a small double-drum hoisting engine to expedite the "spotting" of the cars for loading at the bins (Fig. 1). With a level track alongside

Fig. 1. Arrangement for "Spotting" Cars

the bins, a cut of two to four cars can be handled, the operator having complete control of the cut in either direction.

Locomotive and Cars—The transportation of the material from the pit to the plant is best accomplished by the use of hopper-bottom or standard bottom-dump railroad ballast cars hauled by a four-wheel switching locomotive of about 40 tons weight. The tendency here has been to use too light a locomotive. The maximum hauling capacity of a 10-ton, 0-4-0 locomotive on a 3½% grade with a track resistance (not including curvature) of 20 lb. to the ton—a figure none too liberal for the general run of gravel-pit tracks—is about 150 tons.

For regular work a locomotive should be used at not more than about three-fourths of its maximum capacity. This is not only advisable from an economical point of view, but it will also lengthen the life of the locomotive and provide for emergencies and a possible future increase of output. When it is considered that even 3½% grades are often exceeded in hauling out of the pit and up to the top of the track hopper, often over light and poorly surfaced tracks having excessive curvature, the necessity of using a locomotive of ample hauling capacity becomes apparent.

Preparation of the Material

Preparation of the material should begin in the bank or deposit. If this material has not a rough graduation from coarse to fine, the production of a uniform graduated material is going to be extremely difficult and costly if not impossible. Many so called gravel banks are really sand banks containing only a very small percentage of gravel. Moreover, the small amount of gravel contained in such banks is often extremely coarse; with a bank

jumping from sand to 6-in. stone, no amount of crushing and reduction within reason is going to produce a material of uniform graduation. Too much care cannot be exercised in the examination of a deposit before operations are begun.

GRADUATION OF MATERIAL—The producer's bank material and his market requirements often make uniform graduation extremely expensive. As an instance, the writer has in mind a producer whose deposit runs high in the ¾- to ¼-in. material. In order to produce a uniformly graded material of from 1½ in. to ¼ in., it is necessary for him to take out a large amount of this ¾- to ¼-in. material.

There is but a comparatively small demand in his market for this ¾- to ¼-in. material; as a result, this must often be sold at an actual loss; which, of course, increases the cost of production of the 1½-in. material. A well graded material, however, is generally worth the price, considering the saving that can be effected in the cement bill by the use of such material.

Fig. 5 shows an analysis of a concrete gravel produced by a plant operating in the Middle West. This gravel is 1½-in. material, uniformly graded, down to sand. This analysis shows what can be done in the matter of graduation when a plant is operating under favorable conditions. This analysis is an average of several hundred carloads, a test being made of samples taken from every three cars of material shipped on this particular contract. The dotted line (Fig. 5) shows the ideal graduation or

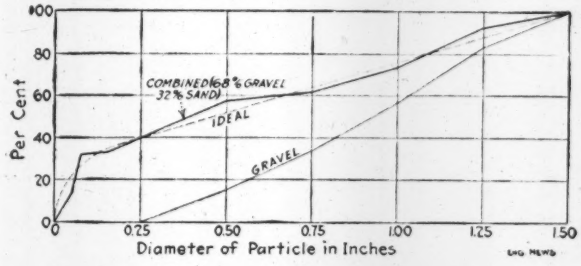


FIG. 5. TYPICAL GRAVEL ANALYSIS

mixture according to experiments by Fuller. To show the effect on the graduation of mixing sand with the material, 32% of a coarse, well graded sand was mixed with 68% of the gravel, with the results shown by the analysis curve in Fig. 5.

[A second article will describe screening and washing plants.—ED.]

Patents on Bituminous Road Construction Since 1900*

Over 300 United States patents on road construction have been issued since the year 1900. J. H. Amies, of Easton, Penn., inventor of "Amiesite," a cold-laid asphaltic concrete, has taken out the largest number—34 patents, seven of which were taken previous to 1900. His patents apply to various processes and methods of construction, such as the use of fibrous material incorporated in asphaltic mastics; processes for eliminating heating plants by the use of benzine, naphtha and the like; processes for granulating asphalt for shipment and then heating on the work; processes for making adhesive, fragments of stone previously coated with asphalt mixtures, and numerous other combinations, mixtures and methods.

The other chief figure in patent-road construction has been the late F. J. Warren, of Boston, Mass., who took out or controlled 30 patents (1900-1911) for methods of work, etc. The best known, of course, are "Bitulithic" and "Warrenite." Mr. Warren came from a family which, for many years, had been engaged in the business of importing and handling asphalt. While connected with the street department of Newton, Mass., he first became interested in the application of asphalt to streets and roads. His first patent dates from Jan. 5, 1900. He is generally credited as being a pioneer in the construction of modern asphaltic-concrete road surfaces.

Mr. Warren's other patents relate to the use of different fluxes, using more mineral ingredients, use of asphalt for surface applications, preservative for wood paving blocks, preparing concrete aggregate for shipment, a multi-layer road construction, temporary liquifiers, a mastic to receive a loose layer of rocks, and several patents on apparatus and machinery. The "Bitulithic" pavement was originally patented in 1901, and subsequent patents were issued in 1902, 1905, 1908 and in 1909.

It would seem from a study of the list of titles that patents have been issued covering every phase of bituminous road construction from the refining of asphalt and tar to their use in any form on roads and streets, although probably by far the greater number of these patents have never been tested in the courts.

Numerous patents have also been taken out in England for the use of tar on roads, although tar was applied to macadamized roads in London as far back as 1820. Until recently the tar used came from gas works without refining. Now, there are several costly plants in England for refining tar for highway uses and the product is placed on the market under such trade names as "Tarmac," "Tarvia" (which is also made in this country by the Barrett Manufacturing Co.), and many others. Generally, patents are on materials rather than processes.

*From information supplied by J. B. Gray, 135 N. Ave. 62, Los Angeles, Calif.

An Early Patent for a Grouted Concrete Pavement—In January, 1829, a British patent was granted to one William Hobson, Gent., for an improved method of paving streets, described in the "Journal of the Franklin Institute" of that period as follows:

Instead of picking up the ground loose (as is the practice in the present mode of paving), ram the ground on which the paving is to be placed, well down, until it is as solid as possible, to a form corresponding with the form of the surface the paving is to take when finished. The stones shall be sorted so as to be nearly of an equal depth; mix up gravel or small fragments of stone with lime and water into a composition or kind of coarse mortar, and lay a bed (of sufficient thickness, to allow for the irregularity of form in the bottom of the stones) of this composition, on the ground which has been previously rammed, and in this composition place the paving stones, and grout them full with finely sifted gravel or coarse sand, mixed up into a liquid state with lime and water, in the same proportions as the composition the stones are laid in.

All the paving done in one day must on the same day be well rammed to an even surface, and when so done must again be grouted full, with fine gravel or coarse sand, mixed up with lime and water, as before. This must be done with each portion of paving on the same day on which the paving is executed; and this method of ramming and grouting must be followed up on each day as the paving proceeds, and when so done it would (if practicable) be desirable that the part paved should be left without carriages being permitted to go over it for three or four days, in order to let the composition of lime and gravel, or stone, set and harden, and it will then become firm and solid, and, if the lime is of a proper quality, impervious to water.

This method if applied to paving done with pebbles or unsquared stone, will be found advantageous in a proportionate degree to paving done with squared stones. I recommend that the lime to be used in this method of paving should be stone, or gray chalk lime, as lime of that description will set and harden in water, and if of a good quality the proportions of one measure of lime to four or five measures of gravel or small fragments of stone will be sufficient.

Two Striking Steel Bridges on the Lake Erie & Eastern R.R.

Two of the steel bridges on the new double-track Lake Erie & Eastern R.R., in Youngstown, Ohio, contain various strikingly original features. Both happen to be skew bridges, but to secure smooth-running track they are detailed with *square ends*. The constructive arrangement of these ends is different in the two cases. Further, one of the two bridges—the plate-girder bridge, Figs.1 and 2—has a remarkably individual floor construction. There are other novelties in general design, details and equipment, the latter including fender girders to protect the trusses from effects of derailment, and blast plates over railway tracks below to protect the underside of the bridge from the abrasive action of locomotive exhaust.

Three-Span Plate-Girder Bridge with Continuous Expansion

About opposite the center of Youngstown, just south of the city water-works filter plant, the line crosses on a skew over the Baltimore & Ohio R.R. The latter has two main tracks and two sidings at present, but may later add two more main tracks. To fit this condition, the crossing is designed with a middle span over the four main tracks, and on either end a span over the siding. The abutments were built square, while the piers are necessarily skew, as shown in Fig. 1.

On account of the floor-construction, noted below, it was necessary to avoid expansion movements between the several spans. The three spans are coupled together by having sole-plates continuous under adjoining shoes,

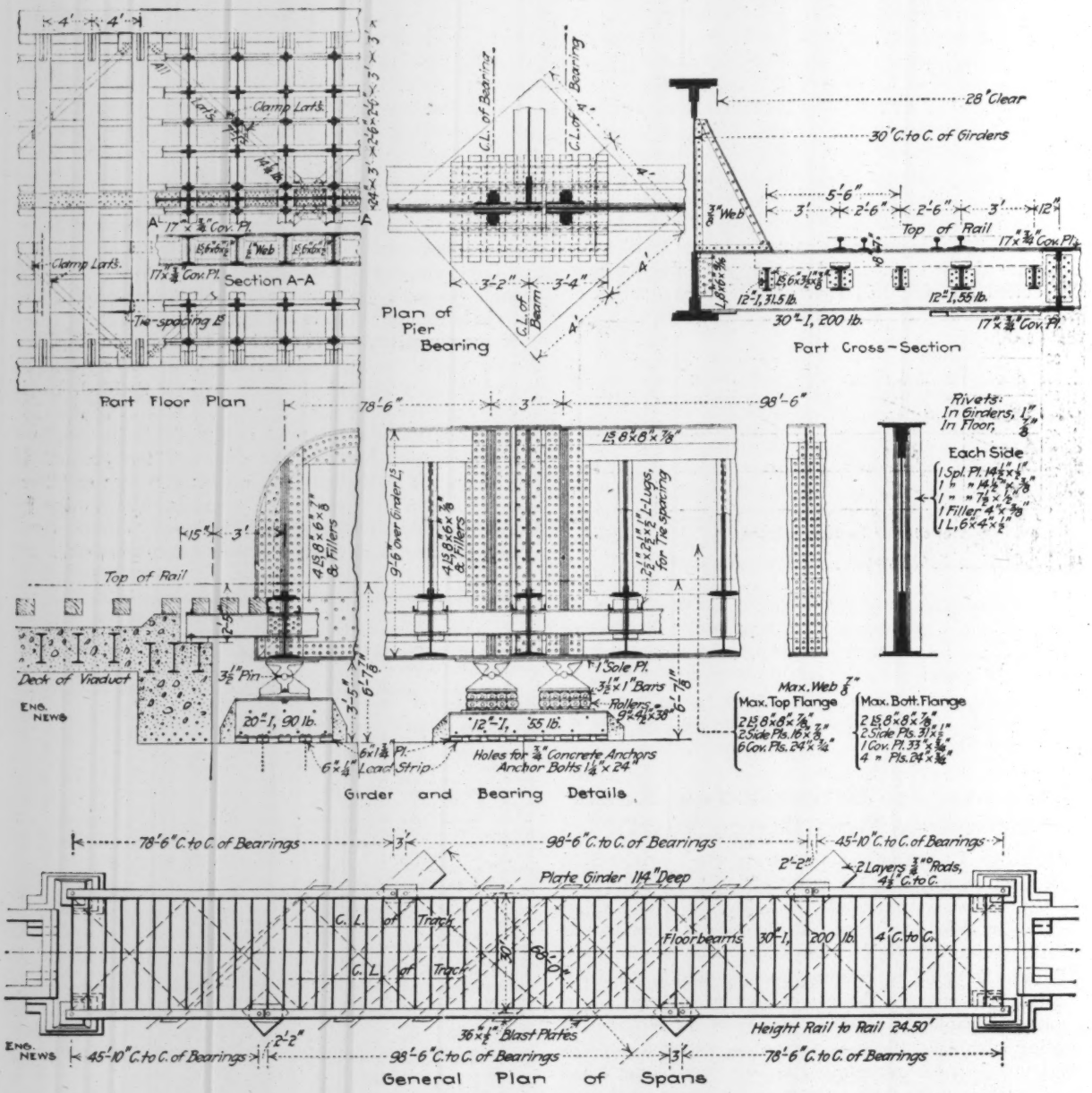

Part Floor Plan
Section A-A
Plan of Pier Bearing
Part Cross-Section
28' Clear
30' C. to C. of Girders
Top of Rail
Deck of Viaduct
Girder and Bearing Details
Rivets: In Girders, 1" In Floor, 7/8"
Each Side
Max. Top Flange
Max. Bott. Flange
78'-6" C. to C. of Bearings
98'-6" C. to C. of Bearings
45'-10" C. to C. of Bearings
Plate Girder 114" Deep
C. L. of Track
Floor beams 30"-I, 200 lb. 4' C. to C.
36"x1/2" Blast Plates
Height Rail to Rail 24.50'
General Plan of Spans

Fig. 1. Three-Span Plate-Girder Crossing over Six-Track B. & O. Roadbed; Lake Erie & Eastern R.R., Youngstown, O.

and only the two bearings at one end are fixed, while the other six are expansion bearings. A detail in Fig. 1 shows the connection of adjoining spans at the shoes.

FLOOR CONSTRUCTION—The floor of this bridge consists of 30-in. I-beams at 4-ft. spacing, as floor-beams, and short I-beam stringers cut into the 4-ft. panels. There are four stringers per track, with a view to supporting the ties in such complete manner as to practically prevent the chance of breaking through the floor in a derailment.

The use of what is equivalent to bridging in the floor is a novelty in steel bridge work. Along the longitudinal center line of the bridge a strong longitudinal girder is formed by cutting in longitudinal diaphragms between the floor-beams and riveting a flange-plate on top and on the bottom the full length of the bridge. A thorough distribution of loading among the floor-beams is secured by this artifice. The flange-plates of the longitudinal girder are riveted to the diaphragms only, and not to the floor-beam flanges, as nothing would be gained by also attaching to the latter and their flanges would be weakened.

Another novelty is the provision of angle clips on the tops of the stringers to form abutting blocks to locate the ties. This not only holds the ties in position but prevents their being placed so close to the floor-beams as to form dirt pockets.

The laterals of the bridge are channels laid flat and placed underneath the stringers. They are supported at each end and at the crossing by attachments to their gussets, but in addition, to prevent rattling, are pinned to a stringer at an intermediate point by plate clips.

There is a break in grade on the bridge just over one of the piers. This, of course, suits only the girders on one side, while for the girders on the other side the break in grade comes within the length of a span. On this side, the attachment of certain floor-beams had, therefore, to be adjusted, both in the angle between web of floor-beam and the vertical line of the girder, and in the seating plate or gusset between bottom flange of floor-beam and bottom flange plate of main girder. These seating plates had to be planed to the proper taper (0.3%). All floor-beams are set with webs normal to the grade of track; that is, where track is level the webs are vertical, while where track is on 0.3% grade the webs are normal to this grade line.

The piers of the bridge are in alignment with the skew; this arrangement involves minimum interference between the masonry and the clearance of the tracks under the bridge. The grillages resting on the piers, however, are set parallel to the bridge axis and therefore run approximately on the diagonal of the pier. This is shown in the pier-top detail in Fig. 1.

The connection between the ends of the bridge and the abutments is made by short outside stringers which rest on a ledge of the backwall of the abutment; thus there is room under and back of the steel to get at it for painting, etc.* These stringers can carry a tie close up to the curb tie of the abutment. The drawing makes this arrangement clear.

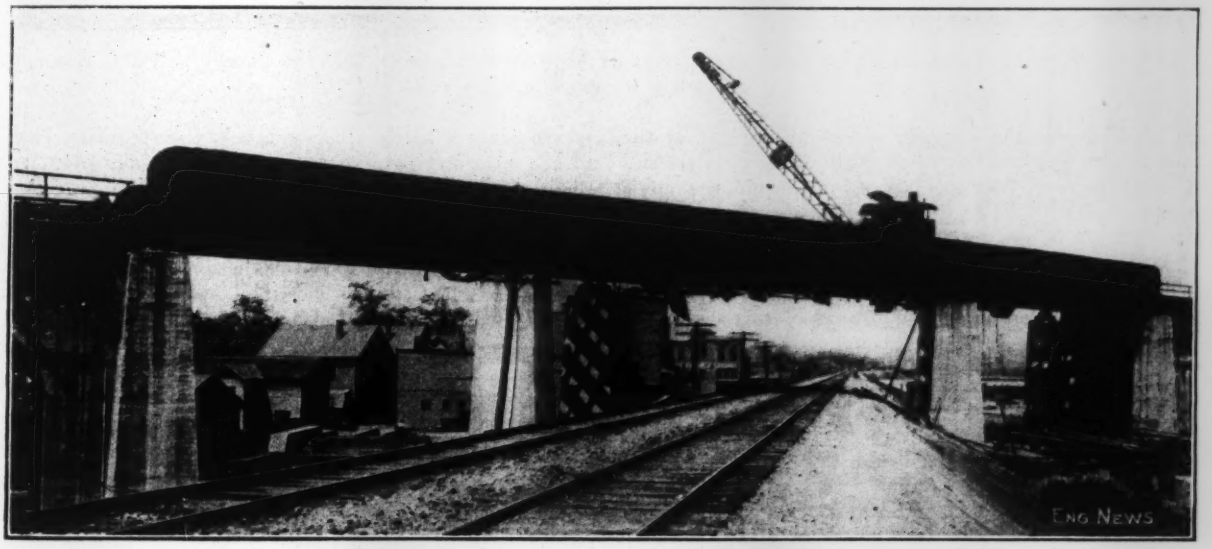


FIG. 2. DOUBLE-TRACK CROSSING OF LAKE ERIE & EASTERN OVER B. & O. RY., YOUNGSTOWN, O.

(Three spans are joined so as to expand together, with fixed bearings at one end. The ends are square, the intermediate supports skew. The floor-beams are 30-in. I-beams, 4 ft. apart, stiffened at midlength by "bridging" formed by a steel longitudinal girder. There are four stringers per track.)

Over each of the six tracks of the B. & O. R.R., a steel blast-plate is attached to the under side of the bridge in order to protect the steel from the abrasive action of the locomotive exhaust. The same device is used on the truss spans of the Mahoning River No. 1 crossing, which crosses a number of railway tracks, as described just below. These plates are attached in a manner to allow renewals to be made when they are worn out.

FOUR-PANEL TRUSS SPANS AT YOUNGSTOWN PUMPING STATION

The first crossing of the Mahoning River is made by a series of plate-girder spans continuous with a plate-gir-

*This same object was kept in view throughout the design of the bridges of this railway. Thus, large cast-iron and steel pedestals are used on all of the bridge-seats, for the same purpose of giving ample working-room around the steelwork.

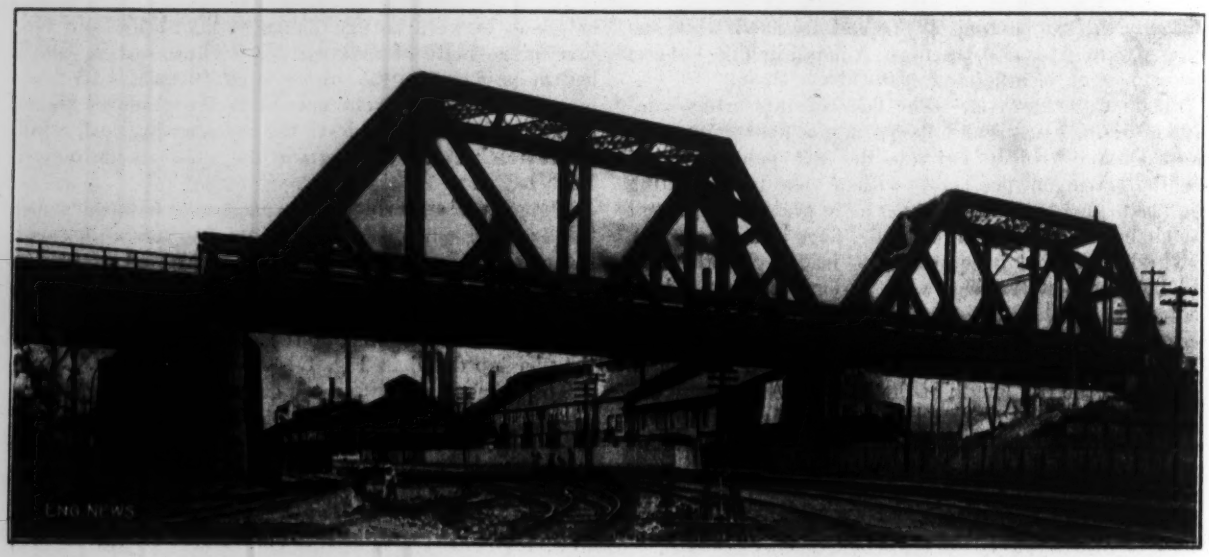


FIG. 3. VIEW OF THROUGH-TRUSS SPAN OVER RAILWAY TRACKS AT MAHONING RIVER CROSSING NO. 1, LAKE ERIE & EASTERN R.R.

der viaduct over the territory of the filter plant of the Youngstown water-works. Just north of the river a series of eight railway tracks is crossed alongside the city's pumping station. For this crossing two through-truss spans of 192 ft. are employed. They have a number of ingenious and original features.

The spans are skew, but their stringers are made to end square. At either end of the set of two spans, the main abutment is built square and carries the stringer ends. As in the case of the B. & O. crossing, this is done

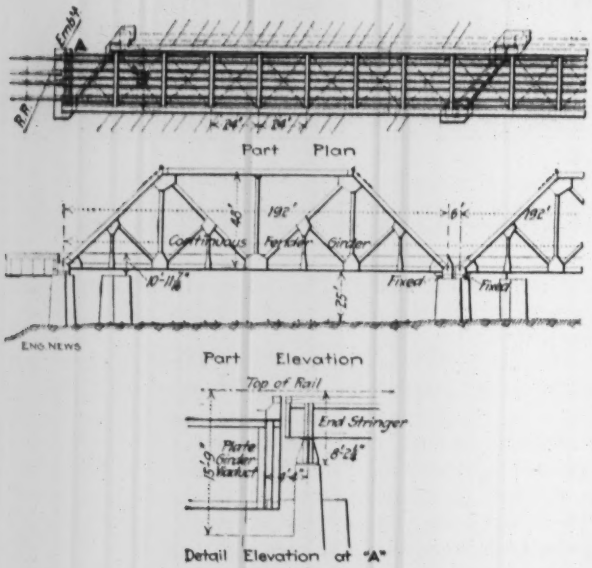


FIG. 4. MAHONING RIVER CROSSING; ELEVATION AND PLAN OF TRUSS

for smooth riding of trains, which in the opinion of the L. E. & E. engineers cannot be secured when there is a skew break in the roadbed. The end of the advance truss rests on a separate pier set forward of the abutment. At the junction of the two spans the end half-panels are merged into a single stringer-panel; the stringers, part in one span and part in the other, are not supported at the pier. This arrangement is shown by the plan and elevation in our drawing, Fig. 4.

The general outline of these trusses is quite unusual. A four-panel truss is used for the 192-ft. span, giving main panels 48 ft. long. These are subdivided, however, by a hanger-and-substrut system, so that the floor panels

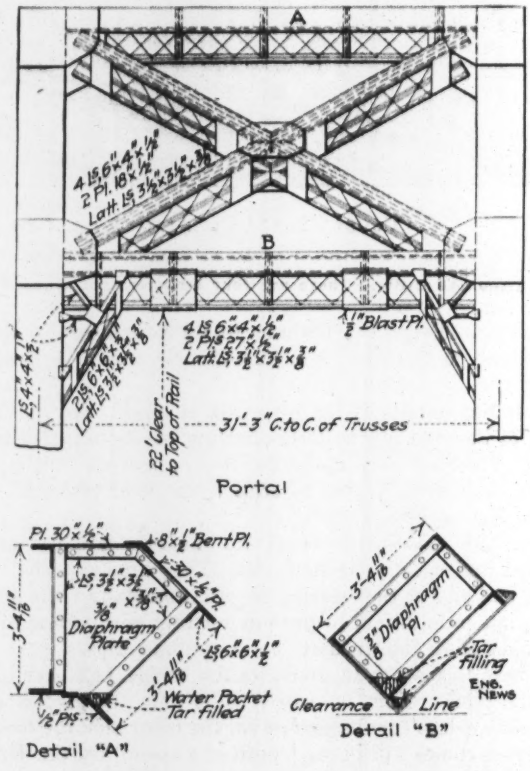


FIG. 5. MAHONING RIVER CROSSING; DETAIL OF PORTAL BRACING

are 24 ft. long. The photograph, Fig. 3, shows well the peculiar chunky appearance of the resulting structure.

Fender girders or "skid girders" are used on this

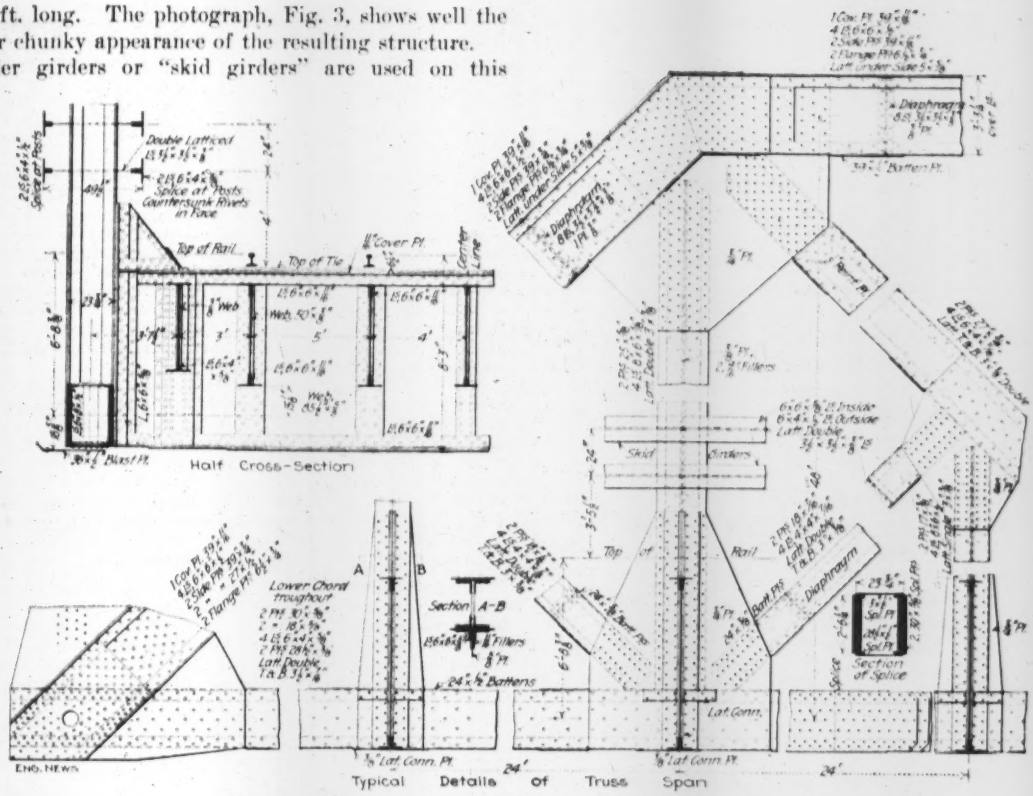


FIG. 6. MAHONING RIVER CROSSING; DETAIL OF TRUSS

bridge in precisely the same arrangement as used on the great Beaver bridge of the Pittsburgh & Lake Erie R.R., built some years ago. A double line is used, 2 ft. apart vertically, the lower one being 4 ft. above the base of rail. The flanges of each of the girders are made continuous from end to end by splices at all posts; the trackside face is made smooth by putting the splices inside and countersinking all rivet heads on the face.

The floor arrangement includes seven stringers: four rail stringers (one under each rail), a middle stringer, and two outer stringers. Thus both ends of the tie are supported. This arrangement, similar to common practice on the Pittsburgh & Lake Erie R.R., is adopted to reduce the chance of any destructive effect of derailment upon the floor, just as the skid girders are intended to protect the trusses.

A further item of protection against derailed equipment is the provision of spacer-blocks between ties. The standard width of space is 3 in. The blocks are attached to the side of the tie and extend from top to bottom of tie. Three blocks are used in each space.

The two spans being connected by their stringers, no relative expansion movements are permissible at the central pier, just as in the case of the B. & O. crossing. The solution is different, however. The fixed support is on the central pier, and the bearings at both abutments are expansion bearings. At the central pier the abutting ends of the trusses are carried jointly on a single riveted pedestal, as sketched in Fig. 4.

Some of the detailing is shown in Fig. 6. As will be seen there, the details are typical for heavy riveted bridge construction. Novelties are found in the use of narrow reinforcing bars on the front and rear edges of some of the chord battens, in the use of asphalt filler to eliminate any water pockets as, for instance, in the portal struts, and in the use of blast-plates over the tracks below. These plates are steel 36x½-in., riveted below the lower lateral system, with support at stringers and laterals.

The portal construction is exceptionally heavy. The lower strut is additionally supported by small brackets in the corners of the clearance diagram. All latticing here is of angles (Fig. 5).

These bridges were designed by Albert Lucius, Consulting Engineer, New York City, for the engineering department of the Pittsburgh & Lake Erie R.R., under J. A. Atwood, Chief Engineer, A. R. Raymer, Asst. Chief Enginer.

The First Concrete Pavement Constructed in Schenectady, N. Y., which has recently been completed, has some interesting features. It is a one-course pavement, 7 in. thick, of 1 : 2 : 4 concrete, made of crusher-run stone graded to 1 in. in size. Expansion joints are placed at an angle of 75° to the curb. William B. Landreth, City Engineer, writes to us, under date of Oct. 27, that "while theory could easily prove that there is no advantage in placing the joints at an angle to the curb, we have decided to give the diagonal joint a practical trial. It is not straining anyone's credulity, however, to believe that the weight of a vehicle may be carried across such a small depression on three wheels." The street is 24 ft. wide, and these expansion joints are placed every 20 ft. These expansion joints are ½ in. wide and are filled with several varieties of joint filler, the intention being to observe the action of these various fillers during the fall and winter, in hopes of finding the most suitable one for the given conditions. In constructing the pavement, the gutters have been made deep enough, and the crown of the pavement is of a shape, that when the pavement is worn to an extent to make repairs no longer economical, the city will be able at moderate cost to place on the old concrete a 2-in. asphaltic-concrete surface. This is the first real concrete pavement in the city, although a short experimental strip was built some years ago.

Kansas City Specifications for Creosoted Wood-Block Paving

By Clark R. Mandigo*

SYNOPSIS—The new specifications for wood-block paving at Kansas City aim to cover more completely and thoroughly than usual the treatment of blocks, this being recognized as a key to the successful pavement. The care of and method of laying the blocks on the street are also covered fully. A few extracts from the specifications are included, but the major part of the article is a discussion of the principal specification clauses and the reasons therefore. A method is described of utilizing wood-block on grades of 5 to 8% by use of special open joints.

In general, specifications for creosoted wood-block paving are indefinite in many of the essentials, as though the engineer preferred to place the responsibility on the block manufacturer and the contractor. This is especially true in the clauses covering the creosote oil and the methods of treatment, and accounts in a measure for the variation in quality of different pavements in the same city.

Kansas City's creosoted wood paving block specifications were open to these objections, although a number of pavements with only minor defects had been laid under them; and now that the ten-year maintenance guarantees on most of the asphalt pavements in the heart of the retail district of the city are expiring, it has been decided to repave immediately with wood blocks, instead of attempting to repair the worn-out sheet asphalt surface.

In redrafting specifications for wood block, an attempt has been made to insure first-class construction in every particular by rational and economical methods, to eliminate as far as possible the nuisance of bleeding, buckling and slipperiness.

Specifications

A few of the more important specification clauses are here given.† These and others are discussed in detail in the following columns:

BLOCKS

TREATMENT—The method of treatment must be thorough and up-to-date, containing the necessary air-tight cylinders, steam pipe, boilers, vacuum and force pumps, tanks, gages, etc., and shall be carried on in accordance with the best modern practice under the joint supervision of the manager of the plant and the city engineer or his representative. During the process of treatment, the blocks shall be subjected to a thorough steaming of from one to four hours, as required by the city engineer, and then to a vacuum of from 22 to 26 in. of mercury, during which time the temperature in the cylinder shall be at all times above the boiling point of water under the existing vacuum. After the moisture and sap extracted by the steaming and vacuum have been drained from the cylinder, the vacuum shall be destroyed by the admission of the creosote oil to completely fill the cylinder, and not by the admission of air. Pressure of from 100 to 200 lb. per sq. in. shall then be applied and maintained until 16 lb. for traffic streets and 18 lb. for residence streets of the creosote oil has been forced into and retained in each cubic foot of timber. The pressure shall be gradually applied, and if in the opinion of the city engineer, better results can be obtained, the maximum allowable pressure may be fixed at any point less than 200 but more than 100 lb. per sq.in., and maintained at that figure long enough for the wood to absorb the specified amount of oil. The temperature of the oil after entering the cylinder shall at no time be less than 150° F. or more than 240° F. The blocks, after treatment, shall show a satisfactory penetration of oil throughout. All blocks which are in any way defective or which have been badly warped or checked in the process of treatment shall be rejected. Before removing the charge from the cylinder, the blocks shall be given a steam bath lasting at least one-half hour to clean off all the surplus oil.

INSPECTION—The manufacturer shall furnish all appliances necessary for tests and all labor which may reasonably be required in removing material for examination. The oil tanks and treating cylinders shall be provided with necessary gages, thermometers, drawoff cocks, etc., affording adequate means for determining the absolute weight of oil retained in the blocks. The contractor shall furnish a copy of the plant record showing a complete statement of each operation in the creosoting process.

FOUNDATION

MORTAR CUSHION—Upon the concrete foundation, which has previously been cleaned, there shall be spread a layer of sand and portland cement mixed in the proportion of one part cement to four parts sand. The cement and sand shall be mixed dry until the mixture has a uniform color throughout and shall be spread on the foundation not less than ½ in. nor more than 1 in. in thickness, the depth being sufficient to bring the wood blocks to the finished grade of the street, as shown on the plans. The mortar cushion shall be carefully shaped to the true cross-section of the roadway by means of a properly made template covering at least one-half the width of the portion of the street to be paved. The template shall be drawn along guide rails or wood strips, placed next the curb and in the center of the street, which have been carefully laid to grade. Where there are street-car tracks on the street, they may be used as a guide for one end of the template. After the blocks have been laid on the cushion prepared in the above described manner, and after they have been rolled, but before any joint filler is placed, the surface of the pavement shall be thoroughly wet so that the mortar cushion may receive enough moisture to cause the cement to set.

WEARING SURFACE

EXPANSION JOINTS—Before commencing the laying of the blocks, boards 1½ in. thick shall be set on edge next the curb. Any projections or unevenness on the face of the curb shall be removed so that the board will fit snugly against the curb. After the blocks have been laid and rolled as hereinafter specified, these boards shall be removed and the space left shall be cleaned out and filled flush with the top of the blocks with asphaltic cement. All joints around manhole covers, catchbasins, valve boxes, etc., shall be filled with asphaltic cement at the same time.

LAYING BLOCKS—When delivered on the street, the blocks must be closely piled and covered to protect them from undue exposure to the weather. They shall be wet occasionally and prior to laying them in the street they shall be sprinkled until they are thoroughly soaked with water. Against the boards, placed to form expansion joints next the curb, and after the sand cushion has been properly prepared, two rows of blocks are to be placed longitudinally of the street, with the fiber of the wood vertical, close jointed sidewise, and with a slight joint, not exceeding ⅛ in., between the ends of the blocks. The blocks in the rows shall be made to break joints with a lap of at least 2 in. Against these longitudinal rows of blocks shall begin the laying of the blocks in the body of the pavement. These blocks shall be laid with the fiber of the wood in vertical position to true line and grade, and at right angles to the curb, in uniform, straight, parallel rows, using a sledge and plank occasionally to drive the blocks close together sidewise and to straighten the rows. The blocks shall be laid with a slight opening not exceeding ⅛ in. between the ends of the blocks. The blocks shall break joints at least 2 in., and no closure shall be used less than 4 in. long, a piece being cut out of the adjacent long blocks, if necessary, to make a 4-in. closure space. All closure blocks shall be cut to exactly fill the spaces they are intended to close.

*Assistant City Engineer, Kansas City, Mo.

†In general, the specifications are identical in requirements with those adopted by the Association for Standardizing Paving Specifications and all first-class practice, and are omitted here.—Ed.

FILLING JOINTS—On the portions of the pavement where no transverse joints are specified, the joints shall be filled in the following manner: When the pavement is dry, and after it has been swept clean of all dirt, sticks and rubbish, the expansion joints and joints around manholes and catch-basins shall be filled with asphaltic cement, as hereinbefore specified.

SAND FILLER—The joints in the body of the pavement shall then be filled with clean Missouri River sand, heated to a temperature of at least 300° F. and swept back and forth across the pavement until all the joints are full. A slight excess of sand shall be left on the surface of the pavement after the joints of the pavement are filled, to be removed by the contractor without additional compensation, as soon as directed by the city engineer.

ASPHALT FILLER—The joints in the body of the pavement shall then be filled with an asphaltic cement, heated to a temperature of at least 350° F. and squeegeed into the joints with hot iron squeegees until they are full, and all surplus asphalt carefully brushed off the surface of the pavement. A coating of coarse sand or Joplin chats, heated to at least 500° F., shall be immediately whipped into the surface of the pavement, any surplus to be later removed if so required by the city engineer. Where a bituminous filler is used, the filling of the joints shall be done only in clear, dry weather, with a temperature of the air not less than 50° F.

TRANSVERSE JOINTS—Where shown on plans, which will usually be where the street grade exceeds 3½%, transverse joints shall be made by placing an ordinary building lath on edge between each row of blocks, laid at right angles to the curb, and laying the blocks closely against the lath. A slight joint shall be left between the ends of the blocks in each row. It is important that the rows of blocks shall be set as closely against the lath as possible and that the rows are straight. To this end, the rows of blocks must be driven up tight with a sledge and plank at least every fifth row of blocks. The pavement shall then be rolled as hereinbefore specified and all imperfect blocks replaced.

All of the materials entering into the pavement are first specified, followed by an account of the manner in which these materials are to be handled to form a completed pavement. This is a logical separation, but one which is not followed in any other city specification the writer has seen. It makes possible a more clearly worded specification and one in which actual operations of laying the pavement follow one another in close order. While this may not be considered important by some, it is certainly convenient and lessens the probability of the street inspector overlooking some detail which might be lost in the laboratory and plant tests as in the ordinary form of specifications.

OLD FOUNDATIONS—A great many of the streets to be repaved in Kansas City have a foundation in which a local natural cement was used. These foundations are weak at best; all lack uniformity and most of them can be removed with pick and shovel. By allowing the broken concrete from the old foundation to be used as aggregate in the new work, considerable is saved on the cost of foundation, even where additional thickness is required.

WOOD BLOCKS—In regard to the blocks themselves, it is believed that a partially seasoned timber will treat better and wear better than wood which has been thoroughly air seasoned. A seasoning of from four to six weeks is about right.

No 3-in. depth blocks have been used to date. All of the old pavements had 4-in. blocks, while pavements laid the past year, with one or two exceptions where 4-in. blocks were used, have been of 3½-in. blocks.

Only yellow-pine timber is allowed, as this has proved to be most durable, while other woods require different methods of treating, which have not yet been satisfactorily worked out.

TREATMENT OF BLOCKS—In the writer's opinion, the method used in treating blocks has a great deal more to do with subsequent trouble with swelling or bleeding than is generally believed. Anyone familiar with the operation of various creosoting plants knows that the methods in each differ considerably as does the product.

Most city engineers leave the process of treatment entirely with the manufacturer. This is not good practice, as the time in the cylinder is often a very important element. During the rush season, the plant superintendent who wants to make a good showing is liable to omit the initial steaming, force the pressure rapidly and as high as possible, and hurry the whole process. This will crowd the oil into the outside of the block and the pavement is almost certain to bleed badly, and a great deal of the oil is lost under traffic, after which the blocks absorb water and buckle.

With a timber about four weeks from the mill, a steaming of at least two hours should be required with the privilege of continuing it to four hours if thought necessary.

DUPLICATE **City Chemist's Department**

Tests and Analysis Creosoted Wood Paving Blocks

Test No. ____ Mfg. Plant ____ Date ____ 191

Blocks for ____ Contractor ____

MATERIAL

Kind ____ Condition ____ Seasoning ____

Treatment ____ Required ____ lbs. Cu. Ft.

No. Cages ____ Size Blocks ____ Cu. Ft. in Charge ____

MOVEMENT	TIME	TEMP. RANGE	REMARKS
Doors Closed			
Steam Introduced			
Vacuum Commenced			
Creosote Introduced			
Pressure Applied			
Creosote Forced Back			
Air Released			

TANK READINGS

Before Filling ____ Gallons ____ Degrees Fahr.

After Filling ____ Gallons ____ Degrees Fahr.

Low Point ____ Gallons ____ Degrees Fahr.

Final Reading ____ Gallons ____ Degrees Fahr.

Calculated Absorption ____ at Working Temp. ____ at 100° Fahr.

Actual Absorption ____ at Working Temp. ____ at 100° Fahr.

Car No. ____ Initial ____ Date ____

____ Plant Inspector

OIL ANALYSIS

Sp. Gr. at 38° C. ____ Solubility in Benzol or Chloroform ____ %

Distillation up to 100° C. ____ % to 150° C. ____ % to 315° C. ____ %

Petroleum Compounds ____ Raw Tars ____

By ____

By ____ City Chemist

FIG. 1. PLANT TEST RECORD OF WOOD PAVING-BLOCK TREATMENT, KANSAS CITY, MO.

Following this with at least 24 in. of vacuum will remove most of the sap and resinous matter as well as air in the pores of the wood. If this vacuum is destroyed by the admission of the oil and not air, the wood is in favorable shape to get the best penetration.

If, however, the pressure on the oil is run up rapidly—close to 200 lb.—and a pure distillate oil is not used, the pores of the wood become clogged and the heavier portion of the oil remains near the outside of the block. The pressure should be put on gradually and should not be allowed to exceed 130 lb. for a 16-lb. treatment.

A final steam bath after the oil is drained off will clean the blocks and make them easy to handle on the street. A clean block will also take an asphalt filler better.

With such treatment and an oil as described in the

specifications,* almost perfect penetration is obtained. No nuisance is experienced from bleeding even with street temperatures well above 100° F. There will be some bubbles of oil appearing on the surface of the blocks during the first summer, but there will be none of the cake of tar and sand, which tracks over the sidewalks and into stores.

PRESERVATIVE OIL—There has been considerable discussion recently over the use of a pure distillate oil, the claim being made that with such an oil, all chance of bleeding is eliminated. There is no doubt that such an oil penetrates the wood better, and being free from the heavy coal tar lessens the tendency to bleed; but if the methods described above are not followed at the creosoting plant, even this more expensive oil will bleed. While Kansas City has not tried a pure distillate oil, it has good success with the creosote-coal-tar-oil, the so called "doped oil," of specific gravity between 1.08 and 1.10. The 1.12 to 1.14 oil, specified until recently, caused too much bleeding.

It is admitted, however, that the weakest point in the present specifications is the one pertaining to the oil, and it is hoped that enough time can be devoted to a thorough study of oils this coming winter to much improve this section. It is difficult to write an oil specification which will be entirely open, giving each manufacturer an equal chance, and at the same time making it impossible for anyone to furnish an oil complying with the specifications, but not having all the good qualities desired. An oil entirely unsuitable for paving-block purposes, from the standpoint of preservative and staying qualities, could probably be furnished, which would comply with all the requirements of the present specifications.

PAVEMENT CONSTRUCTION

FOUNDATION—The streets in Kansas City carrying numbers of heavily loaded trucks and wagons are being repaved on an 8-in. portland-cement foundation. On account of the increasing speed, as well as weight of loads, absolute rigidity in the base is essential, and while a 6-in. foundation may be ample to support a quiescent load over a considerable area of soft or sunken subgrade, it does not have mass enough to absorb the vibration and shaking due to the rapid passage of a heavy load and may fail under impact. With the ever-increasing sizes of trucks it behooves municipal engineers to be on the safe side in laying pavement, the foundation of which should be good for from 30 to 50 years.

BEDDING—It will be noticed in the specifications that the mortar-sand cushion is mixed and laid dry, the water not being added until after the blocks are rolled. This enables the roller to bed the blocks better and get a smoother surface. A mortar-sand cushion should be used for obvious reasons under all wood blocks, whether along street-car tracks or not.

SPRINKLING BLOCKS—The blocks when delivered on the street should be closely piled and frequently sprinkled (in spite of some recent discussion in the ENGINEERING NEWS). It is not possible in most cities to lay the blocks shortly after coming from the treating cylinder; so that the hot sun and wind during shipment and before laying will soon begin to check them and start the oil on all sides. Piling them close and sprinkling them will keep them cool and normal; more nearly the conditions they will meet after being laid.

EXPANSION JOINTS—All of the expansion joints necessary should be placed between the curb and the first row of blocks. Placing a longitudinal row of blocks between two expansion joints, as is sometimes done, is bad practice, as the single row of blocks will be almost certain to be raised up above the balance of the pavement as the expansion joints close up. Throwing a longitudinal joint any farther from the curb will be a detriment on account of wear.

If the blocks are hammered tight sidewise, in laying, they furnish each other lateral support in the direction of traffic and by friction between the rows materially reduce transverse expansion. A slight joint at the ends of the blocks allows for good penetration of the filler and transverse expansion.

There is no apparent advantage in laying the blocks at an angle to the curb, except possibly on a narrow roadway where vehicles track one another, while the right-angle method is cheaper. Straight rows are also important so that each row of blocks may act as a straight column under compression caused by expansion forces.

JOINT FILLER—On heavy-traffic streets, a sand filler has usually been specified. The sand should be coarse grained. Fine, round-grained sand has no place in any pavement. It should be applied hot and worked back and forth with wooden pushers until the joints are full. If the joints are close, a sand-filled pavement under heavy traffic will soon seal itself and iron out smooth and waterproof.

There is, however, a risk in using sand filler. Some small portions of the pavement may not get traffic, or weather or street conditions immediately following its completion may not be favorable. Municipal engineers, as a rule, believe that a bituminous filler is best for creosoted wood-block pavement, but they are troubled with the difficulty in getting it into the joints where it belongs without leaving a sticky surplus on the surface. By the use of a pure asphaltic cement, with a high melting point and low penetration, put on as described in the specifications, a great deal of the nuisance usual with a bituminous filler can be avoided.

The asphaltic cement described* is very tough and rubbery, at ordinary temperatures, and is not cut back materially by the creosote oil. It should be heated hot enough to run like water, and be immediately brushed back and forth across the surface of the pavement with hot-iron squeegees. These squeegees are made of a slightly curved piece of ¼-in. steel plate about 18 in. long by 2 to 3 in. wide, fastened and braced to an asphalt rake handle.

At least four squeegees should be on hand and they should be kept hot in the fire pot of the asphalt kettle, two being in use while two are heating. If these are used with skill, even the smaller joints in the pavement can be filled with asphalt and only a very thin coating left on the surface of the pavement.

Immediately after filling the joints a slight coating of very hot coarse sand or chats should be whipped into the surface. The sand should be hot enough to cook the

*Same as 1911 specifications of the Association for Standardizing Paving Specifications, except that the specific gravity is 1.08 to 1.10 instead of 1.08 to 1.14, and that the distillate shall not exceed 1½% up to 150° C. (instead of 2%), and not less than 30% nor more than 45% (instead of 40%) up to 315° C.—Editor.

*Penetration at 25° C. with a No. 2 needle weighed with 100 grams, in 5 sec., not more than 5 nor less than 3 mm.; at 0° C. penetration not less than 1 mm. Flash point at least 220° C., melting point not less than 95° C.—Editor.

asphalt remaining on the surface, and not too much should be used so that there will be no surplus to be removed later. It is obvious that this method of applying filler will reduce to a minimum any chance of a sticky surface.

Wood Block on Steep Grades

In Kansas City, nearly all streets have some stretches of more than 3½% grade. If creosoted wood blocks were, therefore, to be used successfully, some method had to be devised for preventing slipperiness on grades. The city has adopted, with some changes, the method* introduced by A. H. Stone, Assistant Engineer of the Kansas City Terminal Ry., in the paving of some of the railway's viaducts. The writer understands that this same method of laying blocks on grades was first used in Vancouver, B. C.*

Special Joint Filler—The method consists of laying a line of ordinary building lath on edge on the sand cushion between each row of blocks, and filling the balance of the joint with stone chats and asphalt after the blocks are rolled. Pavement of this kind has been used successfully on grades of 5 and 6% and there is no reason why it should not be used on grades as high as 8 to 10%.

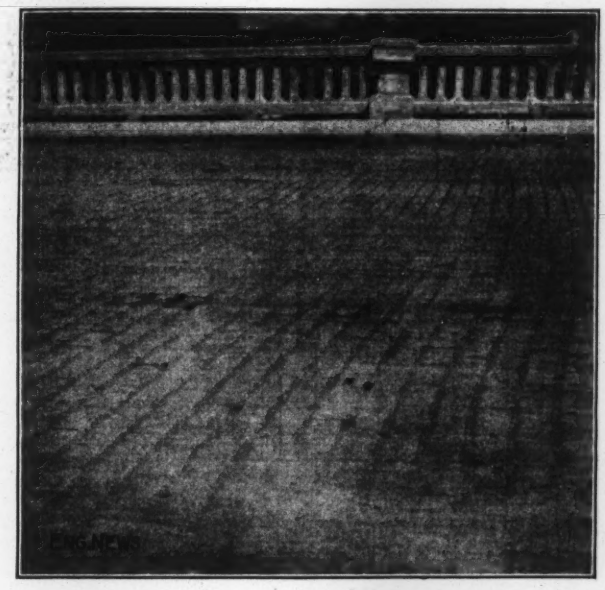


Fig. 2. Wood-Block Pavement on 4.78% Grade under Heavy Traffic; McGee St. Viaduct, Kansas City, Mo.

This statement probably sounds foolish to those who have had trouble with slipperiness on 2% grades, but the writer has particularly observed two wood-block pavements laid with lath joints on 4.78% and 5.17% grades, and subjected to considerable traffic and one short stretch of 11% grade, for more than a year, under all weather conditions; and he has never seen nor heard of a horse falling on any of them.

There is no uncertainty in a team on one of these streets, even with a heavy load; there is no quivering of the horses' legs due to an insecure foothold, but a straight, deliberate, hard-pulling walk possible only when a team is sure footed.

A wood-block pavement laid with lath joints, in the writer's opinion, offers a much better foothold than sheet asphalt or even tar-filled vitrified brick.

Filling Joints—In constructing the open-joint pavement, the rows of blocks must be frequently sledged close to the lath and straight rows obtained. The broken stone which is placed in the joints should be of practically one size and of the largest size that can be swept into the joint. Stone grit should be screened over a ⅜-in. screen before heating, as any fine material in the stone prevents the asphalt penetrating to the bottom of the joint.

The asphalt filler should be heated and applied in exactly the same manner as described for the close-joint pavement in order that there shall be no surplus left on the surface of the pavement.

It is expected the open-joint pavement will not wear quite as long as one with close joints, although at the end of two years there is no evidence to support this. The joints are packed solid and remain nearly flush with the surface of the blocks. The blocks are very firmly bedded and the joint is so small that it is not picked out nor are the edges of the blocks broomed down more than in the ordinary pavement.

There is no fixed rule for the grade at which to change from close to open transverse joints, as this will depend entirely on local conditions as to the general grade on the street to be paved, the class of traffic, the kinds of grades and pavements the local teamsters are accustomed to, and general weather conditions.

Conclusions—Kansas City offered a particularly unfavorable field for creosoted wood-block pavement on account of the topography, practically all streets having some stretches of grades of 4% or greater, while many exceed 6 or 7%. There are long, hot, dry spells during the summer; and no street sprinkling is done by the city.

The entire cost of the paving, repaving or repairing, after the expiration of the guarantee, is assessed in special tax bills directly against the abutting property; so that any attempt to lay a high-priced pavement was met with opposition, until the new pavement could be proved to be cheaper in the long run and entirely satisfactory.

By the use of a heavy foundation, and a mortar-sand cushion, rigidity of the base is obtained, which will hold the block surfacing absolutely true to grade and crown. The 16 lb. of 1.10 oil per cu.ft. of timber, injected clear through the blocks by the method of treatment described, prevents decay and partially waterproofs the block, without, at the same time, causing any nuisance from bleeding. The lath transverse joints will prevent slipperiness on grades; and the asphalt filler waterproofs the surface, preventing swelling and buckling; and if placed as described, does not make an objectionable sticky mass on the surface of the blocks.

There are undoubtedly many points in the laying of creosoted wood-paving blocks which have not been touched upon and many things in the specifications offered which may require changing, especially if they are to apply under different local conditions. They are offered more by way of suggestion than as absolute rules. They are, however, the outcome of careful experiments, in which all of the methods described have been used with success.

*The same method of laying wood block on grades is now being used extensively in Detroit, Mich., where many old granite block pavements are being replaced with creosoted wood-block.—Editor.

Winter Stream Measurements in Western Canada

By P. M. Sauder*

SYNOPSIS—This is a description of some interesting stream measurement work under particularly disadvantageous conditions. It forms a valuable supplement to previous articles in Engineering News, *"Determination of Stream Flow during Frozen Season," by C. Robert Adams, Feb. 2, 1911; "Gaging Minnesota Streams in Winter," by W. G. Hoyt, Sept. 12, 1912;" "Methods of Estimating Stream Flow When Streams Are Frozen," by W. G. Hoyt, Apr. 10, 1913; and "Stream Flow Gagings under Anchor Ice Conditions," by Chester Wason Smith, June 19, 1913.*

The work referred to in this article is that being done by the Irrigation Branch of the Government of Canada, in the Provinces of Alberta and Saskatchewan. All the larger streams in this territory have their sources in the Rocky Mountains. They flow in an easterly or northeasterly direction and after emerging from the foothills converge into two large streams, the North and South Saskatchewan Rivers.

There are, of course, a large number of smaller streams, which drain the prairies and empty into these two rivers; but while some of them have quite a large flow during the early spring, and during wet seasons, the flow, if any, is always very small during the winter months. Even the flow of the larger streams is comparatively small during the winter months.

The Bow River at Calgary, Alberta, may be taken as typical of the streams heading in the mountains, and which receive special attention during the winter months. Its flow ranges from a minimum in the winter of about 600 sec.-ft. to an average high-water flow of about 10,500 sec.-ft. in summer, and the highest known flood due to the combined effect of warm weather melting the snow in the mountains, heavy rains and a cloud burst, is estimated at 54,000 sec.-ft.

*Chief Hydrographer, office of the Commissioner of Irrigation, Calgary, Alta., Canada.

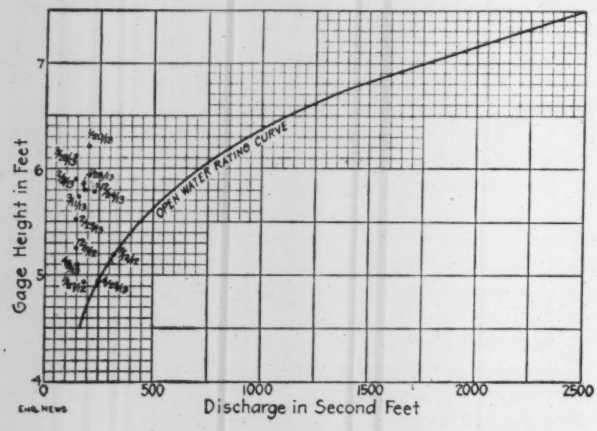


Fig. 1. Open-Water Rating Curve for Spray River near Banff, Alberta

(The open-water curve is based on gagings made during the years 1912 and 1913, and is well defined. On Nov. 12, 1912, ice had not started to form, and on Apr. 25, 1913, the river was clear of ice. Ice conditions started about the end of November and continued until about the middle of April. The plotted measurements show how impossible it is to draw a rating curve when ice conditions prevail.)

Formation of Ice and Ice Conditions

Perhaps the greatest difficulties in ice measurements are met with in the early part of the winter, just as the streams are commencing to freeze up. Especially is this true in the swift-running streams in or near the mountains. Needle and anchor ice often forms in large quantities in rapids, and flowing in masses with the water make gagings very difficult and unreliable. Even after a permanent ice cover is obtained at the gaging station, this ice will, in some cases, obstruct the channel below the station and cause "backwater."

A further difficulty is that the surface ice usually forms along the edges of the stream for some time before forming in the center of the channel. At first, this may be broken away if the stream is small and open-water measurements made, but later it is necessary to take some observations through holes in the ice along the edge. As

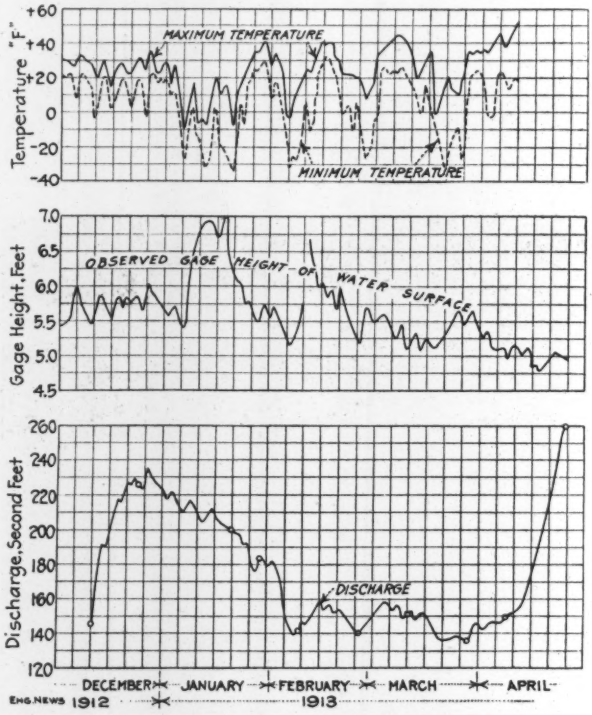


Fig. 2. Observations of Gage Heights on Spray River near Banff with Corresponding Maximum and Minimum Temperature and the Estimated Daily Discharges for the Winter 1912-1913

(The circles on the discharge curve indicate actual discharge measurements. Note the rise in gage height in January and February, when the temperature was lowest and the discharge measurements showed that the flow was decreasing.)

the streams get farther away from the mountains their velocity decreases, and fewer rapids occur along their course. There is then less trouble with needle and anchor ice, and a permanent ice cover forms much more quickly.

In many cases the section used during the summer is very unsuitable for making measurements during the winter. It may be: (a) too wide and shallow or flowing in two channels during the winter, due to low water; (b) partially open due to swift-running water or warm water running in; (c) affected by needle and anchor ice either by flowing in the water, or causing backwater; (d) located where the snow drifts over the ice to a great depth; (e) that it is likely to have a rough ice cover or pile up with ice, due to swift water and a rough bed; (f) that there is a tendency for ice jams to occur, with consequent backwater, etc.

The typical curve, however, differs from that obtained from an open-water observation in that it is drawn back more at the surface, owing no doubt, to greater friction between the ice and the water as compared with the water and the atmosphere. As a result there are two points in the vertical at which the thread of mean velocity occurs under an ice cover. These points are near 0.2 and 0.8 of the total depth below the bottom of the ice, and the mean of the velocities at these two depths will give fairly accurate results; but when close estimates of the discharges are required, and the conditions are not very favorable, the vertical-velocity method should be used.

It is found that when all the holes are opened on a small swift stream, there are sometimes vertical pulsations of the water in the holes, which affect the velocity readings. This can usually be avoided by only opening one hole at a time, and filling it in again with ice and

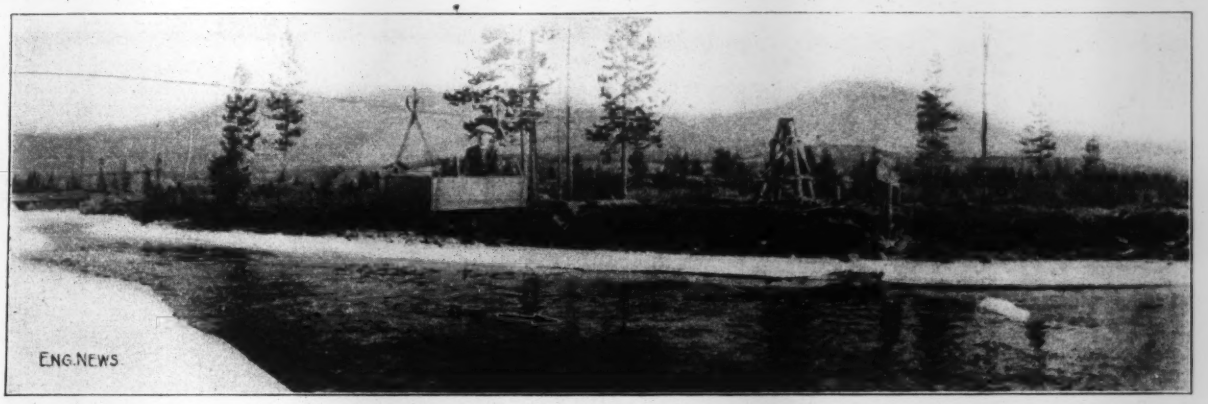


FIG. 3. GAGING STATION ON PIPESTONE RIVER NEAR LAGGAN, ALBERTA, IN EARLY WINTER 1912-1913

It is, therefore, often necessary to choose a new section for winter observations. This should be done before the freeze-up, for then, the width, depth, uniformity of flow and conditions above and below can be easily noted. The most suitable stations for winter measurements are those which have a long stretch of very smooth, sluggish water above, and a rapid fall below.

DISCHARGE MEASUREMENTS

In winter as in summer, the daily discharges of a stream are computed from frequent discharge measurements and daily gage-height observations. The discharge measurements are made through holes in the ice from 5 to 10 or even 20 ft. apart, depending upon the size of the stream, and large enough to allow the current meter to pass through freely.

The gagings are made in the same manner as at open sections except that the depth of the stream is taken as the distance from the bottom of the ice to the bed of the stream. The soundings, however, are always referred to the surface of the water in the holes, the distance from the surface of the water to the bottom of the ice being measured and subtracted from the soundings to obtain the depth.

The vertical velocity-curve method is usually used for the determination of the mean velocity in the vertical. A curve is plotted for each vertical, and the mean velocity is determined in the usual manner. These curves vary greatly as to form for different kinds and conditions of channel.

snow as soon as the observation is finished. It can also be overcome by inserting a thin sheet of galvanized tin or iron at the bottom of the hole, after the meter has been lowered into the water. The meter should always be held near the upstream side of the hole.

In using the meter, care must be taken to keep it under the water as much as possible to prevent ice from forming around the bearings. It is a good plan to clean and oil the meter indoors before starting out to make a gaging.

GAGES AND GAGE OBSERVATIONS

The gage is usually read once each day, the observer noting the elevation of the water as it rises in a hole cut through the ice, the height of the top of the ice, the thickness of the ice, presence of needle or slush ice, snow on top of ice, ice jams, and any sudden changes in temperature. To do this, the observers are provided with an ice chisel for chopping holes, and an L-shaped ice scale to measure the thickness of the ice.

A difficulty which arises, in obtaining the thickness of the ice is that in a hole kept open for some time the ice wears away around the bottom of the hole, and may make it necessary to cut a new hole near-by, or enlarge the original.

Any form of gage may be used, but the chain gage is the most satisfactory, as the staff gage, being frozen to the ice, heaves with it, and also in cutting away the ice from around it the figures are effaced. The automatic gage gives trouble with the well freezing over.

FIG. 4. ICE CONDITIONS AT THE REGULAR GAGING STATION ON PIPESTONE RIVER NEAR LAGGAN, ALBERTA, DURING THE WINTER 1912-1913

FIG. 5. ICE CONDITIONS AT THE GAGING STATION ON SPRAY RIVER NEAR BANFF, ALBERTA, TAKEN ON MAR. 5, 1912

FIG. 6. ICE CONDITIONS AT THE GAGING STATION ON KANANASKIS RIVER NEAR KANANASKIS, ALBERTA, TAKEN MAR. 1, 1912

ESTIMATES OF DAILY DISCHARGE

While the runoff, particularly during the winter months, does not vary directly in accordance with the precipitation, the rate at which it reaches the streams is, of course, dependent almost entirely upon the climatic conditions. The climate in the mountains is subject to great extremes, but during the winter almost the entire precipitation is in the form of snow.

There is, therefore, very little surface runoff and the flow of the streams comes almost entirely from the glaciers, groundwaters and lake storage, and except for the losses due to freezing and the slight increases, due to the melting of snow and ice by chinooks (warm winds), the flow in the streams would remain constant or would change gradually.

There are, however, certain local conditions in Western Canada which make it exceptionally difficult to make estimates of the daily discharge during the winter. The gage height in many cases fluctuates very much, and often sudden rises or drops occur. These rises are often

FIG. 7. ICE CONDITIONS AT THE REGULAR GAGING STATION ON BOW RIVER NEAR LAGGAN, ALBERTA DURING THE WINTER 1912-1913

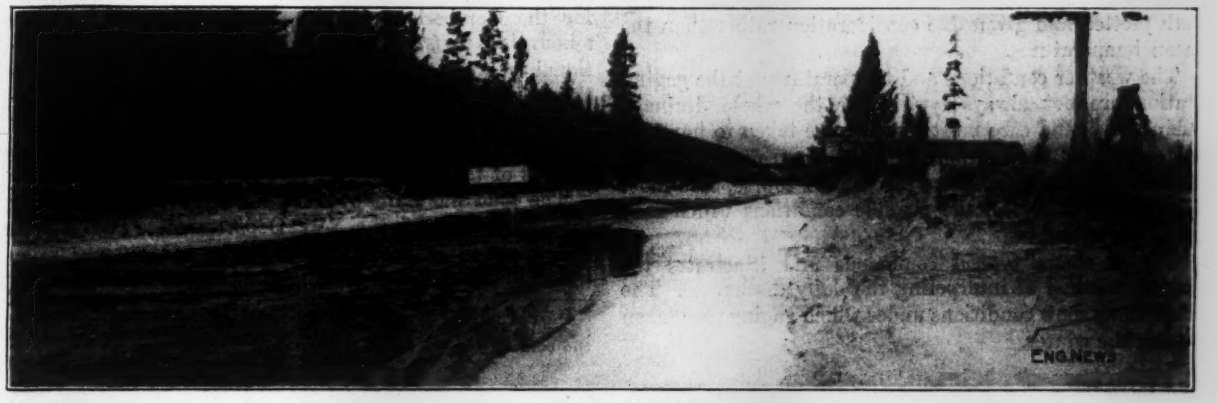


FIG. 8. GAGING STATION ON BOW RIVER NEAR LAGGAN, ALBERTA, IN EARLY WINTER (NOTE THE SLUSH ICE FLOATING IN THE STREAM)

FIG. 9. ICE CONDITIONS AND GAGING TRENCH AT THE REGULAR GAGING STATION ON PIPESTONE RIVER NEAR LAGGAN, ALBERTA, ON FEB. 28, 1912

FIG. 10. MASS OF ICE IN DEVIL'S CREEK NEAR BANKHEAD, ALBERTA, CAUSED BY TURNING IN WATER DURING VERY COLD WEATHER

explained by the fact that during very cold spells a great deal of slush, frazil and anchor ice is formed and chokes up the channel, thus raising the surface of the water, when in reality the discharge is decreasing. Then, again, a chinook causes a sudden rise in temperature and the discharge is often increased while at the same time the gage height gradually lowers, evidently because the warmer weather and water have melted out a lot of the ice from

the channel and given it a greater carrying capacity.

In order to make reliable estimates of the daily discharge, gagings must be made at short intervals and the weather conditions and temperatures in the whole of the drainage area above the station must be very carefully studied.

W. G. Hoyt, District Engineer, Water Resources Branch, U. S. Geological Survey, has made a very exhaustive study of methods for estimating the flow when streams are frozen. The various methods described by him in the article in ENGINEERING NEWS on Apr. 10, 1913, and modifications of them are used. The graphic method of interpolation has been found to be most generally applicable, but as the precipitation during the winter months has so little effect upon the runoff during that period, it is seldom plotted on the sheets. It is also considered that the extremes and ranges of temperatures are better guides for interpolation than the mean temperatures and the minimum and maximum temperatures are both plotted and given due consideration rather than the mean temperatures.

The weather conditions and temperatures at the gaging station are not always typical for the whole drainage basin above, and care must therefore be taken to have the meteorological observations made at some other place, or if necessary, at two or more places. Of course, care must be taken to study all the possible conditions which may affect the estimates.

Fig. 2 shows typical conditions and illustrates the graphic method of interpoling the daily discharges. The other views show conditions under which gagings are taken during the winter.

Rebuilding and Surfacing the Old National Pike with a Concrete Pavement*

The rebuilding of the old Cumberland or National Pike is of historical as well as engineering interest. The section which lies in Ohio will probably soon be improved throughout the whole length at an expense of about $2,000,000. A typical section, 24 miles long, between Zanesville and Hebron, is now under construction. It is being surfaced with concrete under joint appropriations of the U. S. Office of Public Roads, the counties of Licking and Muskingum, and the Ohio State Highway Department, at a cost of $436,017, including new bridges and culverts.

HISTORY OF THE OLD NATIONAL PIKE—The first appropriation of $30,000 for the Cumberland Road was made in 1806. This stretch extended from Cumberland, Md., to a point near Wheeling. Subsequent legislation for the Cumberland Road carried total appropriations amounting to $7,000,000, paid entirely out of the national treasury. These amounts seem small today, when the 1914 appropriations of states, counties and the national government total about $250,000,000, but they were large considering the scanty population and resources of the times.

The road was built by the Federal government, under the supervision of the War Department. The eastern end averaged in cost from $9000 to $13,000 per mile, which included heavy grading and massive stone bridges.

*Information from J. P. Beck, of the Universal Portland Cement Co., 208 South La Salle St., Chicago, which furnished the cement for the work.

FIG. 1. OLD NATIONAL PIKE, OR CUMBERLAND ROAD EXTENSION, ABOUT ONE-HALF MILE EAST OF GRATIOT, OHIO

In eastern Ohio grading was much less and the cost was in the neighborhood of $3500 per mile. Rivers and creeks were spanned by handsome stone bridges and culverts.

PRESENT CONDITION—The pike is still in fairly good condition when it is considered that practically no attention has been paid to its maintenance since it was turned over to the various states and later to the counties. Many of the original stone bridges are well preserved.

The class of houses along the Pike distinguish it from other roads. They are substantial, many being of

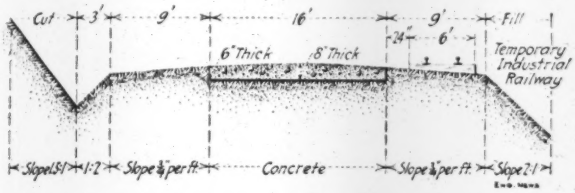


FIG. 2. TYPICAL CROSS-SECTION

stone. Some of the old inns, which were built at intervals of about 15 miles to serve travelers at the end of each day's travel, are still in existence.

NEW WORK—On. Apr. 15, 1914, the contract for the first section of new concrete pavement was awarded. Work was immediately started from both ends by grading gangs operating a traction engine, grader, rooter, roller, steam shovel and 50 teams. Bridge and culvert builders followed soon after, succeeded by gangs laying track along one side of the roadbed. As soon as trains were running, concrete mixers were put in operation.

The pavement is 16 ft. wide, 6 in. thick at the sides and 8 in. in the center and is laid on a flat subgrade. Expansion joints of tarred felt are placed 30 ft. apart at an angle of 75° with the center line.

Preliminary crowning of the concrete surface is done with a strike board made of three 1x6-in. boards bolted together. The lower edge is shaped to the desired crown, shod with a $\frac{3}{16}$-in. plate and additionally reinforced by two small angles. Long iron hooks fitting into eyes serve to move the board, which is held erect by means of ½-in. round steel handles. After the surface has been struck off two or three times it is brought to a still better crown by means of a template similar to, but lighter than, the strike board. Two men operate the template by lifting it a few inches, letting it fall and then moving it forward about 2 in. after each blow.

All curves over 12° are elevated on the outer edge to a maximum of 8 in. The superelevation is calculated for a speed of 30 mi. per hr. This elevation is accomplished by rotating the section of roadway about its horizontal center line so that the cross-section remains the same, the outer edges being elevated and lowered at the subgrade, respectively.

Steel forms are used and have proved very satisfactory. Three complete paving outfits are in operation. The mixers are of the boom and bucket type with batch capacities of 10 cu.ft. Although each crew of 35 men is rated as capable of laying 600 ft. in a day, there has been no time when all were working at maximum capacity so that the best day's run to date has been 1520 lin.ft. (for all the outfits). Wheeling to the mixer is done with a double set of barrows, one set being loaded while the other set is being wheeled and dumped into the mixer.

The contractor has had a private switch built from the railroad at each end of the road. The materials are unloaded to stock piles by clam-shell buckets from where they are loaded to elevated bins opposite. A 3-ft. gage industrial railway serves to haul materials. Cars are run under the hoppers and loaded as required.

A train, consisting of an engine, six cars, a second engine and two more cars, can be operated over a maximum grade of 5%. On steeper grades the last two cars are dropped, the two engines run up with the six cars and the last engine backs down and gets the two remaining cars. A complete train can be loaded in an average of 15 min. Cement is loaded by hand directly from the railroad cars to flat-cars on the industrial railway and hauled to site along with the other materials.

Very little difficulty has been encountered with cars jumping the track or with spreading rails. That the industrial railway has proved an economy is shown by the fact that the cost of hauling, 12c. per ton-mile, is about half the estimated cost of hauling by teams. As the length of haul increases the cost will be further reduced.

A railroad crosses the highway about two miles from the west end. This 2-mile stretch is being supplied with material by means of trains consisting of a traction engine and trailer cars. The cars are pulled into the railroad yard, loaded by clam-shell buckets directly from the stock pile and hauled to the site. The one tractor, hauling four or five 2-cu.yd. cars over this portion of the road, which is practically level, supplies all the materials for the single mixer.

Water for mixing and curing is supplied by pumping stations set at 4-mile intervals. These stations pump 2 miles in either direction through 2-in. mains. The sand and gravel are washed, screened and remixed to the proper gradations. At one end of the road gravel is used for coarse aggregate and at the other end crushed stone, the mixtures being 1 : 1½ : 3 and 1 : 1¾ : 3 for the gravel and crushed stone, respectively.

The federal government has three engineers on the work at all times, while the state has eight inspectors who hand in daily reports, which are compiled on cost-data sheets by the government engineers.

This is the largest and most thoroughly organized concrete road job that has ever been carried on by the Ohio State Highway Department and some valuable data will be available, it is anticipated, as the contractor is coöperating with the engineers in the compilation of all cost figures.

The contractor is the H. E. Culbertson Co., of Cleveland, with whom are associated Frank L. Shoemaker, contractor, and H. A. Johnston, and G. S. Allen, of the Globe Construction Co., all of Kalamazoo, Mich. C. H. Moorefield is the U. S. Office of Public Roads representative and R. N. Waid is Division Engineer for the Ohio State Highway Department.

A Damage Suit to Recover for a Poor Bituminous Pavement has been lost by the city of Hutchinson, Kan., because the city engineer failed to notify the pavement company of defects in the pavement. The company guaranteed the pavement for one year. The counsel for the defense argued that the contract stated that the pavement should be kept in good repair for one year, but that a statement had been inserted in the contract which made the city engineer solely responsible for the pavement. The city engineer neglected to notify the company of the defects which developed, and this, the counsel argued, excused the paving company from further liability. The case was decided in favor of the defendant by the United States court at Wichita, Kan., Oct. 1.

Formulas for Locating Frogs and Switches on Circular and Tangent Tracks

By Anders Bull*

The computation of turnouts from tracks changing their curvature between switch and frog points is mostly by analytic methods, the solution being obtained after solving a number of triangles. Little information is to be found on the subject in standard handbooks, although the computations may be very much simplified through the use of worked-out formulas. With this end in view, the table on p. 928 has been prepared.

A variety of cases may arise, according to the features of the main track, the location of the turnout and the quantities to be solved for. However, provided the point to be located falls within a circular or tangent portion of the main track, any problem of this kind permits of a direct solution.

The following denominations will be used:

P.F. = point of frog;
P.S. = point of switch;
P.C.C. = point of compound or circular curve;
P.R.C. = point of reverse curve;
P.T.C. = point of transition curve;
S, R = radius of main track;
r = radius of turnout;
g = standard gage;
n = number of frog;
F = angle of frog;
J, K, L = angles of lead;
d = lead on tangent.

Consider first the general case shown in Fig. 1, representing an inside turnout from a compound curve on the main track, the terms "inside" or "outside" being used in the following according as the frog is on the inside or outside rail of the main track.

The main track is here assumed to be composed of two circular portions with centers at e and c respectively. The location of the switch is supposed to be known, the radius through P.S. forming an angle K with the radius through P.C.C. and intersecting the circle of radius $S + \frac{g}{2}$ at a point d. It is required to find the location of P.F. and the turnout radius corresponding to a frog angle F.

Solution—Through center c, draw a line at an angle F with radius ed and determine its point of intersection b with the circle of radius $R - \frac{g}{2}$. Draw a line through d and b, producing it until it again intersects the inner rail at f. A perpendicular bisecting line df at a will then intersect radius ed at a point i, which is the center of the turnout circle.

This is easily demonstrated by drawing lines if and cf. A circle drawn through f with i as a center must be tangent to the outer rail of the main curve at d and intersect the inner rail at f at an angle $cfi = F$, because:

$\angle\, cfi = \angle\, cfd - \angle\, ifd$; or, since $if = id$ and $cf = cb$:
$\angle\, cfi = \angle\, cbf - \angle\, idf = F$, according to construction.

The circle df represents the outer rail of the turnout, P.F. being determined by the angle J between radius cf and the radius through P.C.C.

*Public Service Commission for the First District, New York City.

To find the value of J, draw line bm perpendicular to ed. Since $\angle\, cfi = F$, we have:

$\angle\, dbm = \frac{1}{2} \angle\, dif = \frac{1}{2}(J + K + F)$. Further:

$$\tan dbm = \frac{dm}{bm} = \frac{ed - ec \cos K - cb \cos F}{ec \sin K + cb \sin F}$$

Substituting:

$$ed = S + \frac{g}{2};\ ec = S - R;\ cb = R - \frac{g}{2}$$

gives

$$\tan \tfrac{1}{2}(J + F + K) = \frac{S + \frac{g}{2} - (S - R)\cos K - \left(R - \frac{g}{2}\right)\cos F}{(S - R)\sin K + \left(R - \frac{g}{2}\right)\sin F} \quad (1)$$

Considering that

$$\tan \tfrac{1}{2}(J + F + K) = \frac{\tan \frac{J}{2} + \tan \frac{F + K}{2}}{1 - \tan \frac{J}{2} \tan \frac{F + K}{2}}$$

and that from the definition, $n = \frac{1}{2} \operatorname{cotan} \frac{F}{2}$; we have by solving for $\frac{J}{2}$ and reducing

$$\tan \frac{J}{2} = \frac{ng - S \tan \frac{K}{2}}{R + 2n \tan \frac{K}{2}\left(S - R + \frac{g}{2}\right)} \quad (2)$$

By drawing line ic and considering the triangles icf and ice we next obtain the following equations:

$$ic^2 = if^2 + cf^2 - 2\, if\, cf \cos F$$
$$ic^2 = ie^2 + ce^2 - 2\, ie\, ce \cos K$$

Substituting: $if = r + \frac{g}{2}$, $cf = R - \frac{g}{2}$, $ie = S - r$, $ce = S - R$, and substituting $\cos F = \frac{4n^2 - 1}{4n^2 + 1}$ and

$$\cos K = \frac{1 - \tan^2 \frac{K}{2}}{1 + \tan^2 \frac{K}{2}}$$

and reducing, we have:

$$r = S - \frac{\left[RS + 2gn^2\left(S - R + \frac{g}{2}\right)\right]\left(1 + \tan^2 \frac{K}{2}\right)}{(2gn^2 + R)\left(1 + \tan^2 \frac{K}{2}\right) + (S - R)(4n^2 + 1)\tan^2 \frac{K}{2}} \quad (3)$$

In equations (2) and (3), J and r are expressed as functions of K. When, however, the location of P.S. is to be determined from a given P.F., the problem is reversed and it is necessary to express K and r as functions of J.

By solving for K in equation (2), we have:

$$\tan \frac{K}{2} = \frac{gn - R \tan \frac{J}{2}}{S + 2n \tan \frac{J}{2}\left(S - R + \frac{g}{2}\right)} \quad (4)$$

which value is substituted in equation (3). The expression thus obtained may be reduced to:

$$r = \frac{\left[R\left(S - R + \frac{g}{2}\right)\tan^2\frac{J}{2} + S\frac{g}{2}\right](4n^2+1)}{(2gn^2+R)\left(1+\tan^2\frac{J}{2}\right) + (S-R)\left(1+2n\tan\frac{J}{2}\right)^2} - \frac{g}{2} \quad (5)$$

From equations (2) to (5), expressions covering all the various cases referred to at the outset may be easily derived, as will be shown through a few examples.

Considering the case of an *outside* turnout from the main track shown in Fig. 1, it is evident that, keeping the turnout in the same place, it will change to an outside turnout if the main track on both sides of P.C.C. is first straightened out and then curved the opposite way. In mathematical terms this is equivalent to reversing the signs of R and S.

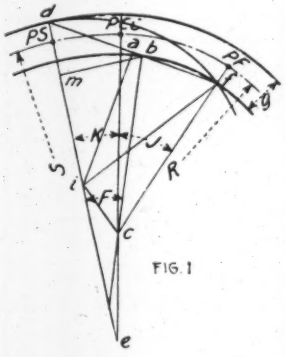


FIG. 1

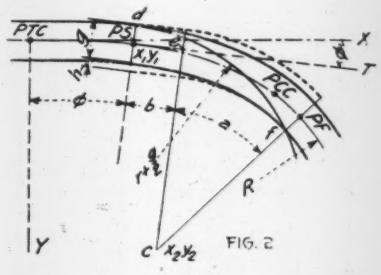


FIG. 2

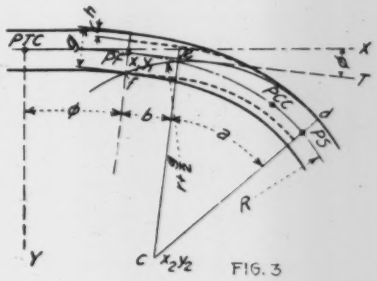


FIG. 3

The corresponding angles J and K, which may be expressed as inverse functions of their radii, would then have to be considered negative. It being more convenient, however, to deal with positive angles, we also reverse the signs of J and K, laying them off to the same sides of P.C.C. as before. If then, J or K comes out negative it is an indication that the frog number originally assumed cannot be used under the conditions given.

By substituting $-R$ and $-S$ for R and S in equations (2) to (5) and noting that $\tan(-x) = -\tan x$, we thus obtain the values for the case considered, as represented by the lower signs in the table. The turnout radius may, in this case, come out either positive or negative, a positive value indicating that at P.F. the turnout and main track are curved opposite ways, while for a negative r they are curved in the same direction (see left-hand and right-hand diagram, respectively).

Similar reasonings are applied in deriving the formulas for a main track made up of two circular portions of reversed curvature: For inside turnouts, reverse the signs of S and K in equations (2) to (5); for outside turnouts, reverse the signs of R and J. In this case, only positive values of r need be considered.

If the main track is made up of one circular and one tangent portion, the value ∞ will have to be substituted for R or S in equations (2) to (5), according as the frog or the switch lies on the tangent portion.

When P.F. is on a tangent, the substitution of $R = \infty$ will make both sides of equation (2) zero, as angle J may be expressed as $\frac{d}{R}$, where d represents the subtended arc as measured along the center line of track. To obtain a definite equation, multiply both sides of equation (2) by $2R$:

$$2R\tan\frac{J}{2} = \frac{2R\left[ng - S\tan\frac{K}{2}\right]}{R + 2n\tan\frac{K}{2}\left[S - R + \frac{g}{2}\right]}$$

Substituting $\frac{d}{R}$ for J, we then have for left and right side respectively:

$$\left(\lim_{R=\infty}\right)\left[2R\tan\frac{d}{2R}\right] = \left[\lim_{\frac{1}{2R}=0}\right]\left[\tan\frac{d}{2R} \div \frac{1}{2R}\right]$$

$$= \left[\lim_{\frac{1}{2R}=0}\right]\left(\frac{d}{\cos^2\frac{d}{2R}} \div 1\right) = d \quad (6)$$

$$\left(\lim_{R=\infty}\right)\frac{2R\left[ng - S\tan\frac{K}{2}\right]}{R + 2n\tan\frac{K}{2}\left[S - R + \frac{g}{2}\right]} = -\frac{2\left[gn - S\tan\frac{K}{2}\right]}{1 + 2n\tan\frac{K}{2}}$$

The limits of equations (3) to (5) are found by simple differentiation, the value of $R\tan\frac{J}{2}$, as found in equation (6) being substituted where convenient.

Similarly, when P.S. is on a tangent, multiply both sides of eq. (4) by $2S$. By substituting $K = \frac{d}{S}$ and differentiating we have:

$$\left(\lim_{S=\infty}\right)\left[2S\tan\frac{d}{2S}\right] = d$$

the other three expressions being obtained from equations (2), (3) and (5), through plain differentiation.

The formulas thus derived apply to inside turnouts. To obtain the corresponding expressions for outside turnouts, simply reverse in each formula the sign of the main track radius (R or S) and the corresponding angle (J or K). Where there is only one main track radius to be considered in the final formulas, this radius has, in the table, been designated by the letter R while for the angle of lead the letter L has been used.

Coming finally to the cases where there are several changes in the curvature of the main track between P.F. and P.S., a typical example of this kind is shown in Fig. 2, representing an inside turnout df (only the outer

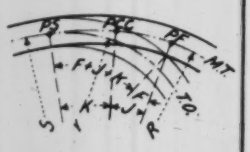
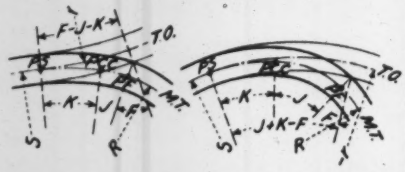
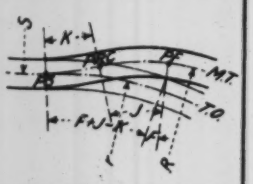
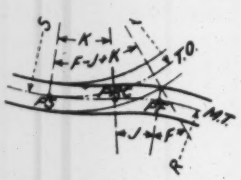
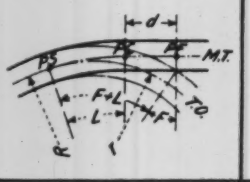
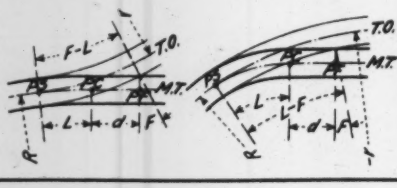
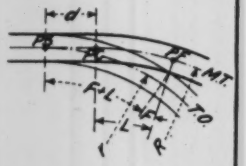
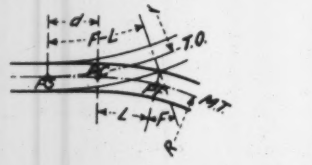
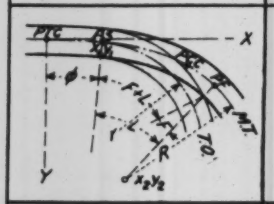
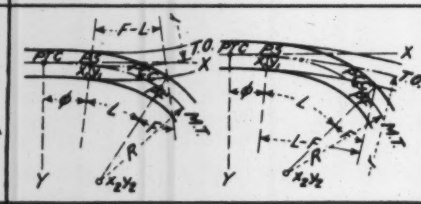
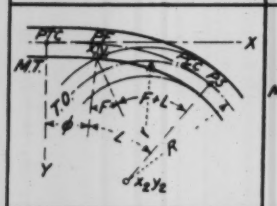
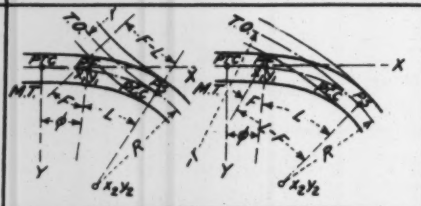
INSIDE TURNOUTS	OUTSIDE TURNOUTS	SOLUTION
		**Frog and Switch on Compound Circular Curves** $\tan\frac{I}{2}=\frac{gn-S\tan\frac{K}{2}}{R\pm2n\tan\frac{K}{2}(S-R\pm\frac{g}{2})}$ ...①; $\tan\frac{K}{2}=\frac{gn-R\tan\frac{I}{2}}{S\pm2n\tan\frac{I}{2}(S-R\pm\frac{g}{2})}$ ...② $r=\pm S-\frac{[RS\pm2gn^2(S-R\pm\frac{g}{2})](1+\tan^2\frac{K}{2})}{(2gn^2\pm R)(1+\tan^2\frac{K}{2})\pm(S-R)(4n^2+1)\tan^2\frac{K}{2}}$ ...③ $r=\frac{[R(S-R\pm\frac{g}{2})\tan^2\frac{I}{2}\pm S\frac{g}{2}](4n^2+1)}{(2gn^2\pm R)(1+\tan^2\frac{I}{2})\pm(S-R)(1\pm2n\tan\frac{I}{2})^2}-\frac{g}{2}$ ...④
		**Frog and Switch on Reverse Circular Curves** $\tan\frac{I}{2}=\frac{gn-S\tan\frac{K}{2}}{R\pm2n\tan\frac{K}{2}(S+R\mp\frac{g}{2})}$ ...①; $\tan\frac{K}{2}=\frac{gn-R\tan\frac{I}{2}}{S\pm2n\tan\frac{I}{2}(S+R\mp\frac{g}{2})}$ ...② $r=\mp S+\frac{[RS\pm2gn^2(S+R\mp\frac{g}{2})](1+\tan^2\frac{K}{2})}{(2gn^2\pm R)(1+\tan^2\frac{K}{2})\mp(S+R)(4n^2+1)\tan^2\frac{K}{2}}$ ...③ $r=\frac{[R(S+R\mp\frac{g}{2})\tan^2\frac{I}{2}\pm S\frac{g}{2}](4n^2+1)}{\pm(S+R)(1\pm2n\tan\frac{I}{2})^2-(2gn^2\pm R)(1+\tan^2\frac{I}{2})}-\frac{g}{2}$ ...④
		**Frog on Tangent, Switch on Circular Curve** $d=\frac{2(gn-R\tan\frac{I}{2})}{1\mp2n\tan\frac{I}{2}}$ ...① $\tan\frac{I}{2}=\frac{2gn-d}{2(R\mp dn)}$ ...② $r=\pm R-\frac{(2gn^2\mp R)(1+\tan^2\frac{I}{2})}{4n^2\tan^2\frac{I}{2}-1}$ ...③ $r=\frac{(2gR\mp d^2)(n^2+\frac{1}{4})}{R\pm2gn^2\mp2dn}-\frac{g}{2}$ ...④
		**Frog on Circular Curve, Switch on Tangent** $\tan\frac{I}{2}=\frac{2gn-d}{2(R\pm dn)}$ ...① $d=\frac{2(gn-R\tan\frac{I}{2})}{1\pm2n\tan\frac{I}{2}}$ ...② $r=\frac{gn^2(2R\mp g)\pm d^2(n^2+\frac{1}{4})}{R\pm2gn^2}$ ...③ $r=\frac{(\frac{g}{2}\pm R\tan^2\frac{I}{2})(4n^2+1)}{(1\pm2n\tan\frac{I}{2})^2}-\frac{g}{2}$ ...④
		**Frog on Circular Curve, Switch on Transition** $\tan\frac{I}{2}=\frac{2n(g\pm h)-b}{2(R\mp bn)+h}$ ...① $r=\frac{gn^2(2R\mp g)\pm(b^2+h^2+2hR)(n^2+\frac{1}{4})}{R\pm2gn^2+2h(n^2+\frac{1}{4})}$ ...③ where: $b=(x_2-x_1)\cos\phi+(y_2-y_1)\sin\phi$ $h=(y_2-y_1)\cos\phi-(x_2-x_1)\sin\phi-R$
		**Frog on Transition, Switch on Circular Curve** $\tan\frac{I}{2}=\frac{2n(g\mp h)-b}{2(R\mp bn)+h}$ ...② $r=\frac{[(g\mp h)(2R+h)\mp b^2](n^2+\frac{1}{4})}{R\pm\frac{g}{2}\pm2n^2(g\mp h)\mp2bn}-\frac{g}{2}$ ...④ the value of "b" and "h" being the same as in case above.

TABLE OF FUNCTIONS FOR g = 4'-8½"

n	gn	2gn²	log gn²	log(4n²+1)	Angle "I"
4	18.833	150.667	1.8769872	1.8129134	14°-15'-00"
5	23.542	235.417	2.0708072	2.0043214	11°-25'-16"
6	28.250	339.000	2.2291697	2.1613680	9°-31'-38"
7	32.958	461.417	2.3630633	2.2944662	8°-10'-16"
8	37.667	602.667	2.4790472	2.4099331	7°-09'-10"
9	42.375	762.750	2.5813522	2.5118834	6°-21'-35"
10	47.083	941.667	2.6728672	2.6031444	5°-43'-29"
11	51.792	1139.417	2.7556526	2.6857417	5°-12'-18"
12	56.500	1356.000	2.8312297	2.7611758	4°-46'-19"

g = Gage of Rails n = Number of Frog
x_1, y_1 = Coordinates of Switch- or Frog Point
$x_2 y_2$ = do. of Center of Circular Curve
ϕ = Slope Angle of Main Curve at Point $x_1 y_1$
For Locating Frog Points Use Formulae ① and ③
" " Switch " " " ② " ④
Use Upper Signs for Inside, Lower Signs for Outside Turnouts.
For Outside Turnouts, a Negative Value of "r" Indicates that Turnout Curves Same Way as Main Track (Right Hand Diagrams).

FORMULAS FOR LOCATING FROGS AND SWITCHES ON CIRCULAR AND TANGENT TRACKS, DEVISED BY ANDERS BULL

rail shown), having its switch on a transition and its frog on a circular curve, it being required to locate P.F.

A tangent T is drawn to the center line in P.S. and from the center of the circular curve a perpendicular ce to this tangent. The main track is thereupon replaced by the one shown by dotted lines, consisting of a tangent portion b, parallel to the tangent T, and a circular portion a, concentric with the circular main track curve and having an outer and inner rail radius of $ce + \frac{g}{2}$ and $R - \frac{g}{2}$ respectively. Since this change will not affect the position and curvature of the rails intersecting at the frog (f), the problem is reduced to one of those previously considered.

Applying the formulas for an inside turnout having its frog on a circular curve and its switch on a tangent, it should be noted that the gage of the dotted track is wider than the standard by an amount

$$h = ce - R$$

Substituting in equations (1) and (3) in the table, for g, the value $g + h$, and for R, r and d, the corresponding values $R + \frac{h}{2}$, $r - \frac{h}{2}$ and b, we obtain the formulas for the case in question by a simple reduction.

Fig. 3 represents an inside turnout fd, having its frog on a transition and its switch on a circular curve, it being required to locate P.S. By drawing a tangent T to the center line in P.F. and a perpendicular ce, we find in a similar way that by substituting for the original track the one shown by dotted lines, we may apply the formulas for an inside turnout having its frog on a tangent and its switch on a circular curve, the quantities to be substituted for g, R, r and d being, in this case, $g - h$, $R + \frac{h}{2}$, $r + \frac{h}{2}$ and b, h having the same value as above.

The corresponding formulas for outside turnouts have been derived in a similar way.

As to the quantities h and b, they may be considered as the rectangular coördinates of the center c, referred to the given point as origin and the tangent T as X-axis. Knowing the coördinates of the center (x_2, y_2) and the given point (x_1, y_1) in any other rectangular system, we therefore have:

$$h = (y_2 - y_1) \cos \phi = (x_2 - x_1) \sin \phi - R$$
$$b = (x_2 - x_1) \cos \phi + (y_2 - y_1) \sin \phi$$

Where angle ϕ is the slope angle of the center line at the given point.

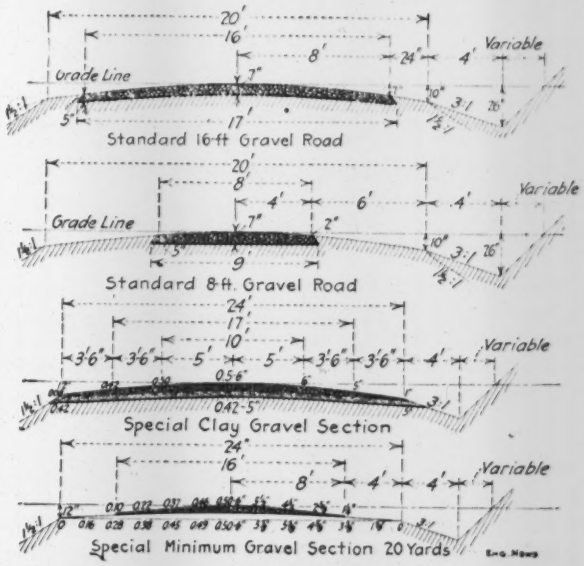
When, as in the above examples, the lead is partly on a transition, P.T.C. is conveniently chosen for origin.

Gravel Roads in Minnesota

In Minnesota, most of the road surfacing is being done with gravel. The specifications are varied to suit local conditions, as the roads are built on all kinds of soil and the quality of gravel must vary accordingly. It is very difficult to secure gravel that is properly graded for road making, and the engineers of the State Highway Commission usually consider themselves fortunate if appropriations can be secured sufficient to haul gravel from available pits without going to extra expense for screening and remixing or grading.

The standard sections for gravel roads with paved widths of 8 ft. and 16 ft. are shown in the accompanying cut. There is shown also a special 16-ft. section which has been adopted; this requires 20 cu.yd. per station, and has proved very satisfactory where sufficient funds are not available for the standard 16-ft. roadway. The clay and gravel section shown in the cut has been adopted for sandy locations where adequate funds for standard construction cannot be obtained.

The 8-ft. width is not considered advisable as a rule, for the maintenance by dragging tends to mix the shoulder material with the gravel, and the turning out of vehicles on this narrow roadway also breaks down the edges so that the gravel is soon lost. It is considered that two applications of the special 20-cu.yd. section would be more satisfactory on heavy-traffic roads which must be built at low cost. The specifications provide that



STANDARD AND SPECIAL ROAD CROSS-SECTIONS ADOPTED BY THE STATE HIGHWAY COMMISSION OF MINNESOTA

when the 8-ft. gravel road is built on heavy soil it is advisable to place a 2-in. layer of gravel for a width of 4 ft. on each shoulder, thus protecting the edges of the roadway proper.

These two special sections, therefore, represent a compromise practice designed to meet conditions where the financial factor is the governing factor as to road improvement. They indicate very strongly the attention which highway engineers are giving to local conditions, to enable good roads to be made at a minimum cost where necessary, both by the use of local materials and by adapting the improvement work to the funds available. This practice undoubtedly increases the popularity of state-aid in road improvement, and is calculated to offset the deep-seated popular suspicion that state authorities in charge of roads will seek to build them in an expensive manner.

The roadbed is graded to the sections shown and the 9-ft. or 17-ft. base is well rolled or otherwise compacted. When the fill is over 5 ft. high, the roadbed width is made 24 ft., with a crown or rise of 12 in. It must be free from ruts and waves or undulations, and gravel must not be deposited upon a wet or muddy roadbed. The gravel must be deposited to rope lines set out at the proper

distance from the center lines, and the specifications provide that the gravel must be shoveled into place and not dumped on the road in such a manner as to develop a wavy surface after settlement. Even when the wagon loads dumped on the road are carefully leveled there is very apt to be greater density at the dumping plant, which eventually results in the wavy surface referred to.

In general, the gravel is measured in the wagon boxes as delivered on the work, and checks showing the amount in each load are furnished to the driver by the inspector in the employ of the county.

The gravel is furnished by the county, but is required to be approved by the engineer as to its quality. It must be free from strippings and from stones over 2 in. in diameter, while stones over 1 in. diameter must be kept at least 4 in. below the finished surface. The gravel must not contain more than 10% of sand and 15% of clay, but these limiting proportions may be altered at the direction of the engineer in the surfacing of heavy clay roads or sandy roads. When a clay base is required (section C) it must be deposited in advance of the gravel, distributed to uniform width and thickness, and either rolled with a 5-ton roller or dressed with road machine and road drag.

The gravel is finished to a firm and even compact surface, either by means of a roller (not less than 5 tons) or by a system of maintenance by means of dragging and raking for at least 30 days after completion. If for any reason rolling is not done, the work will not be accepted until three months after the gravel is placed, or until it has settled to a permanent base, and the contractor will be required to keep it raked smooth and in good condition until it is accepted by the engineer. This maintenance by the contractor is necessary, of course, to prevent traffic from wearing ruts and holes in the loose gravel.

After the gravel has been thoroughly compacted, the earth shoulder is finished to the section shown, and the whole roadway then rolled or dressed with a road machine and drag.

George W. Cooley is State Highway Engineer and John H. Mullen is Chief Deputy State Engineer. The offices of the State Highway Commission are at St. Paul, Minn.

Concrete Viaduct with 50-ft. Walls

SYNOPSIS—The viaduct carrying Union Ave. over the tracks of the St. Louis (Mo.) Terminal R.R. is mainly a fill between retaining walls, which are of the semi-gravity type and have a maximum height of nearly 50-ft. The tracks are crossed by three slab and girder spans forming a single continuous-girder structure.

One of the works for the elimination of grade crossings at St. Louis is the construction of a viaduct 1190 ft. long carrying Union Ave. over the tracks of the St. Louis Terminal Ry., in the northwestern portion of the city. The line is in a cut in a valley and the track grade remains unaltered, the viaduct having approach grades of about 3% to attain the required elevation. It is 80 ft. wide over the copings, with a 60-ft. roadway, the sidewalks and parapet walls taking up the remaining 20 ft.

The general design is shown in Fig. 1. The structure has three reinforced-concrete spans (of the slab-and-beam type) over the right-of-way; the central span 32 ft. c. to c. of piers and the side spans 36 ft. For the remainder of its length it is a solid fill between concrete retaining-walls. There are only two tracks at present, but there will be additional tracks forming the entrance to a new freight yard. The viaduct was built at the expense of the railway company.

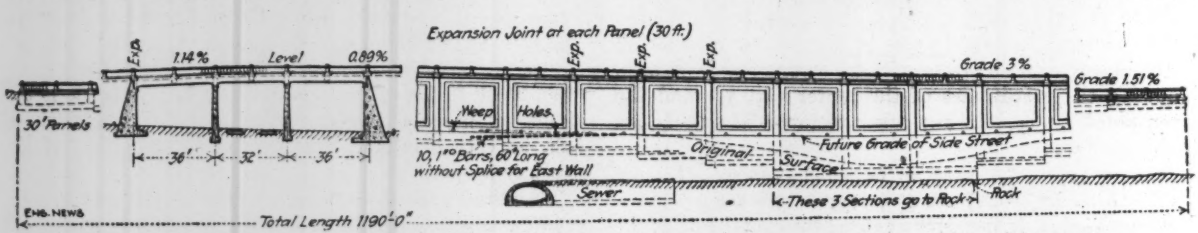


FIG. 1. PART SECTIONAL ELEVATION OF UNION AVE. VIADUCT OVER THE TERMINAL R.R., ST. LOUIS, MO.
(The three spans over the tracks form a continuous-girder structure.)

DESIGN OF RETAINING-WALLS

The special feature of interest is the height of the retaining-walls of the fill. At one point, north of the tracks, the line of the viaduct crosses the bed of an old creek, partly filled in, the flow of the creek being diverted by a pair of cast-iron culvert pipes into a new concrete sewer. This sewer runs under the eastern side of the viaduct for a part of the distance and then makes a turn, crossing under the east wall, as shown. Concrete is filled between the crown of the sewer and the bottom of the wall, and extra heavy reinforcing is used in the bottom of the wall at this point.

For about 200 ft. at this creek bed, it was considered necessary to carry the walls to rock, and here they have a maximum height of about 50 ft. The foundations elsewhere are in the bed of yellow clay above the rock, and no piles have been used. Typical sections are shown in Fig. 2, and at some points there is beneath the bottom a rib or dowel 3 ft. wide and 2 ft. deep.

The walls are of semi-gravity section throughout, and have steel reinforcement in the bottom and inner face, while additional reinforcement is used in the bottom of the east wall where it crosses the sewer. They were designed in accordance with Rankine's theory of earth

pressures; the weight of concrete was assumed as 144 lb. per cu.ft., and that of the earth fill at 110 lb., with a surcharge of 1 ft. allowed for live-loads on the fill.

The walls are in 30-ft. lengths, with expansion joints, as shown. The face of the wall is relieved by the pilasters which mask these joints, while the flat surface in each 30-ft. length is relieved by a slightly depressed panel outlined by a broad depression 18 in. wide. The effect is carried out also in the abutments, the track face of each having one large panel. Each section of the wall has two weep-holes of 4-in. vitrified pipe, placed at the elevation of the future fill against the outer side, and having loose stone piled around the inner end.

The parapet wall is of ornamental pattern with a series of vertical openings. This parapet, with its pedestals, was cast in place after the construction of the walls. Gas lamps will be erected on the pedestals. A rather unusual feature in the construction of this viaduct was the placing of its "cornerstone" with some civic ceremonies. The "stone" is the base of one of the end pedestals, of the parapet, and in this was embedded a bronze box containing coins and newspapers. Some trouble was experienced in finding room for the box between the reinforcing rods.

Reinforced-Concrete Bridge Spans

The three spans over the railway are of the slab-and-girder type, with 14 ribs or girders. The facia girders are 17 in. wide and 52½ in. deep over all, and the inner girders are 23 in. wide and 40 in. deep (including the 7-in. deck slab). The four middle ribs come directly under the rails of the street-car tracks. The design is shown in Fig. 3.

The three spans form one continuous structure, the girders being anchored to the piers and having expansion bearings on the abutments. At each end there is an expansion joint between the slab and the face of the back wall of the abutment. In this is inserted a U-shaped strip of copper which is filled with asphalt. Above this is a filling of tar-paper separating the concrete foundation for the paving on the spans and approaches. The ends of the girders have steel shoe plates embedded and anchored in the concrete, and these rest on steel bearing-plates anchored to the bridge seat of the abutment, as shown. These plates are milled, and are coated with tallow on the contact faces.

Upon the deck slab was laid a course of concrete forming the foundation of the paving, 8½ in. thick at the center and shaped to the proper contour. In this were embedded the ties for the street-railway tracks, and upon it was placed a 1-in. sand cushion for the 3½-in. wood-block paving. The sidewalks have a similar concrete base with a 1-in. top finish. The curbs are of granite, with an asphalt expansion joint between each curb and the wood paving.

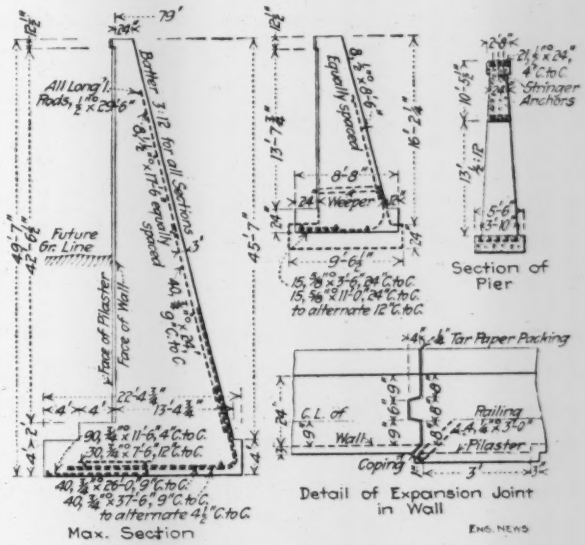


Fig. 2. Sections of Retaining Walls and Piers of Union Ave. Viaduct, St. Louis, Mo.

(The walls are of the semi-gravity type and have a maximum height of nearly 50 ft.)

The piers are of the section shown in Fig. 2, and each is pierced with three arched openings 4 ft. wide to reduce the weight. They were built with rods projecting from the top to form anchors for the continuous stringers. The abutments are similar to the retaining-walls, but with a ledge for the bridge seat and a back wall above this to retain the fill of the approach.

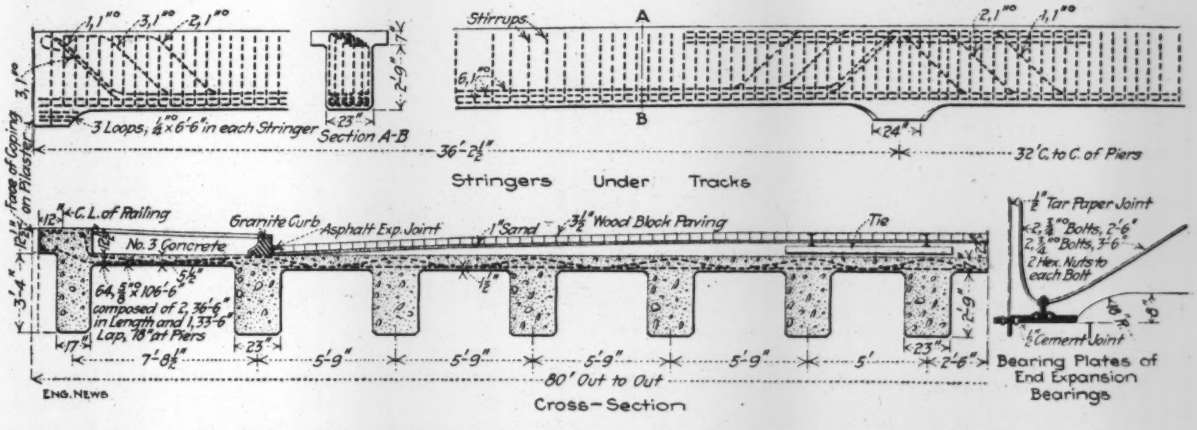


Fig. 3. Track Spans of the Union Ave. Viaduct over the Terminal R.R., St. Louis, Mo.

The spans were designed under the following conditions as to live-loads and stresses: (1) Track stringers; two

electric cars having trucks of 4½-ft. wheelbase, 20 ft. c. to c. of trucks, and loaded with 13,800 lb. per wheel. (2) Roadway stringers; an 18-ton road-roller, with 6 tons on the roller and each wheel (11-ft. wheelbase, 5 ft. c. to c. of wheels). (3) Roadway slab; a concentrated load of 8 tons on an area 4x4 ft., and a uniformly distributed load of 150 lb. per sq.ft. (4) Sidewalk slab; uniformly distributed load of 100 lb. (5) Impact allowance; 50% on slabs, 40% and 50% on stringers under and over 35 ft. long. (6) Maximum fiber stresses for concrete; 650 lb. per sq.in. for compression (cross bending), 25 lb. per sq.in. for shear without shear reinforcement, 125 lb. per sq.in. for total shear on section, steel to carry all diagonal tension. (7) Maximum fiber stresses for steel; 16,000 lb. per sq.in. tension, for cross bending and for shear reinforcement; 100 lb. for the adhesion of deformed bars.

Construction Work

During the construction of the viaduct this section of Union Ave. was closed, being in an outlying section, and traffic was diverted while passengers on the street cars had to walk around the work, using the grade crossing of the next street.

Concrete material was delivered in cars on a siding, and unloaded onto stock piles by a stiff-leg derrick mounted (with its engine and boiler) on a tower or platform some 15 ft. high. The same derrick and clam-shell bucket handled the material from the stock piles to the 200-yd. bins over the 1-yd. concrete-mixing plant, which was located just east of the structure and on the north side of the tracks.

The concrete was discharged into 1-yd. drop-bottom buckets, the bucket standing on a small narrow-gage flat-car, blocking being put on the ends of the car to support the sides of the bucket and carry its drop-bottom doors clear of the car floor. The cars were then moved a short distance on the track (transverse to the center line of the bridge) and stopped under the cableway used to convey the concrete along the line of the walls. The bucket was then raised, run to the desired point over the retaining-wall and dumped into the form.

The cableway was 800 ft. long, with an 80-ft. tower at the mixer end and a single bent 60 ft. high at the further end. It was placed over each wall in turn, and was shifted laterally 80 ft. from one wall to the other without being dismantled; this was done by placing timber dollies under the tower. Handling the 12,500 yd. of concrete by cableway was economical, as the amount of concrete at the ends of the walls is small, and wheeling it in buckets would have been slow and expensive.

The walls were poured in alternate 30-ft. sections to allow for expansion, and 5-ply tar-paper was used to fill the joints. The wall forms were built continuously from the footing to the coping of 1-in. sheeting, nailed to 2x6-in. studding 18 in. c. to c., and held by twisted double No. 8 annealed wires 24 in. apart vertically. This proved ample for the rate of filling, which was arranged not to exceed 3 ft. vertically per hour during temperatures from 30° to 70° F. Owing to the drop of 20 to 30 ft. and in order to keep the concrete from scattering as it hit the tie wires, and so falling onto the heads of the three men in the forms below (spading the aggregate away from the exposed faces), light wooden trays were used with 12x12-in. wooden spouts depending below them. These trays had wire hangers and were set by the cableway, being thus moved readily where needed. The bucket discharged onto the tray.

A crew of 2 enginemen (75c. per hr.), 8 concreters (40c.), 2 laborers (30c.), and a foreman (62c., sufficed to unload the materials and put the concrete into the walls). The plant charge was about $10,000. The bid price for concrete in place exclusive of cement (furnished by the railway company) but including the forms, was $4.85 per cu.yd. For the walls, the batches averaged 0.9 cu.yd. and 175 to 220 batches were mixed daily. During midwinter, 4242 yd. were placed in the northwest wall in 44 consecutive working days of 8 hr. each.

The concrete was made with ½-in. washed gravel as the coarse aggregate. It was 1:2½:5 for the retaining-walls, piers, and abutments; 1:2:4 for the girders and deck slab, and 1:4:8 for the paving foundation. For the railings or parapet walls, the aggregate was ¾-in. binder gravel and washed river sand. The walls were completed to the coping at the sidewalk level, the pedestals and panels of the parapets being built later. In this parapet, some trouble was found in placing the reinforcing steel within the small space of the completed forms. This was overcome by building the forms with the inner side omitted, so that the interior was open for placing the steel properly, after which the side was put on and secured.

The exposed surfaces of the walls were wetted and rubbed down with concrete blocks to remove form projections, etc., and were given a wash of 1:1 grout to secure uniformity of color. The parapet railing was not given any finishing treatment.

The bridge spans had to be built without interfering with the traffic on the railway below, which amounts to about ten trains daily. The three spans were poured together, the forms being supported on framed bents between the tracks. For this part of the work (44,000 yd.) the concrete was distributed in a chute from the head tower of the cableway.

The earth fill between the retaining-walls was deposited by dump wagons, the material being taken from an area along the top of the railway cut, adjacent to the viaduct. Over this area traveled an elevating grader hauled by a steam tractor, loading the earth directly onto wagons moving beside the grader.

It was anticipated that there might be trouble with water in building the work through the old creek bed, as when the sewer was built (1913) a freshet washed out the forms and temporary flume and caused considerable damage and expense. But the season of 1914 was dry, and no trouble was experienced.

Engineers and Contractors

The structure was designed and built under the direction of the St. Louis Terminal Ry. Co.; H. J. Pfeifer, Engineer of Maintenance-of-Way, and A. G. Anderson, Resident Engineer in charge. Brenneke & Fay, of St. Louis, were consulting engineers. The work was done by the Fruin-Colnon Contracting Co., of St. Louis, and was in charge of A. P. Greensfelder, Secretary and General Superintendent for the company. The contract was let in July, 1913, and the work was completed in July, 1914. The contract price was about $110,000, exclusive of the paving of the approaches. The cement was furnished to the contractor by the railway company.

Portable Plant for Asphaltic-Concrete Roads in Chicago

The work of improving main lines of road in the outskirts of Chicago, in order to connect the country roads with the paved streets, was inaugurated in 1913 and was described in ENGINEERING NEWS of Jan. 1 and Sept. 10, 1914. These roads were built of macadam and coated with oil. The amount of maintenance work required has been very high, due partly to the low and wet land, and partly to the tendency of traffic to follow ruts in a road only 18 ft. wide. To eliminate this condition of rapid wear and excessive maintenance, it was decided to cut down the crown and resurface the roads with a 2-in. top of asphaltic concrete.

For this work, under the direction of the Bureau of Streets, a portable plant was purchased, at a cost of $13,000, having all the equipment complete on one railway car. The car is moved from place to place at the outskirts of the city and at each site it is placed on a central track, with a track on one side for the cement car and one on the other side for the oil-tank car, as shown in Fig. 1. The tracks are 16 ft. c. to c. The oil is heated in the tank and pumped to the mixer. The plant with all apparatus folded up for transportation resembles a large furniture car and weighs about 20 tons.

The sand and stone are proportioned and mixed on the ground, and delivered by a bucket conveyor to the dryer, where the material is heated to about 300 ° F. From the dryer it goes to the storage bins, and is drawn off to the measuring bin and the mixer, which is of 15 cu.ft. capacity. Coal or oil fuel may be used, but the latter is employed at present.

For conveying the asphaltic concrete from the plant to the road the city has 20 dump wagons, the number in use depending upon the length of haul. There are also two 5-ton motor trucks, each doing the work of three teams. The average haul is about two miles, with a maximum of five miles. The rolling is done with 10-ton rollers.

The asphalt plant has been turning out 2500 sq.yd. of 2-in. top per day, or 1000 lin.ft. of 18-ft. roadway in nine hours. The Bureau is completing a mile each week at a cost of about 70c. per sq.yd. This includes all cost of preparing the old road and laying the new top. This improvement is expected to last five years without repair, and the maintenance will then be slight in comparison to the old water-bound macadam. It is desirable to have at least 10 in. of stone at the center and 4 to 6 in. at the edges, so that in some cases 3 to 4 in. of new material is laid on the road before resurfacing. The surface is made as flat as possible.

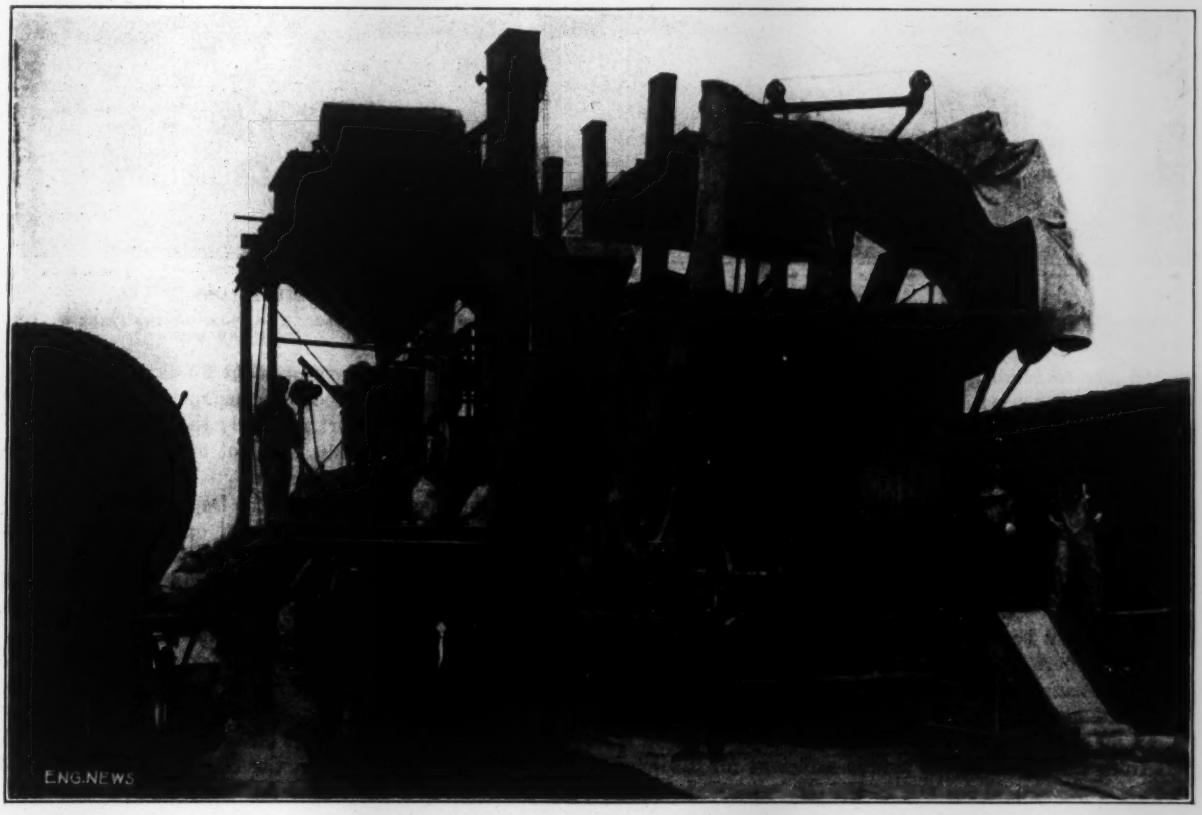


FIG. 1. PORTABLE PLANT FOR MAKING ASPHALTIC-CONCRETE FOR SURFACING MACADAM ROADS ENTERING CHICAGO

The mix averages approximately 6.5% bitumen, 37.2% sand, 52.3% stone, 4% filler. The aggregate is crushed granite (¼ to 1 in.), with torpedo sand and portland cement. The price of granite this year is $2.25 per cu. yd. With the plant running at full capacity, the force at the plant and on the street is composed as shown in the accompanying table.

FORCE FOR ASPHALTIC-CONCRETE ROAD WORK

At the Plant	On the Road
1 foreman plant	1 foreman
1 chief drum man	2 rakers
1 drum man	2 smoothers
1 kettle man	2 tampers
1 mixer man	15 helpers
2 timekeepers and material men	2 watchmen
25 laborers	2 roller enginemen
18 teams	
1 assistant chemist	
2 watchmen	

The work of preparing the old macadam road varies. Where the existing surface is in good condition and has suitable line, grade and contour, the surface is swept thoroughly to remove all the loose particles and expose the rough stone. Any depressions are filled with binder and tamped; in this way the existing road is made parallel with and 2 in. below the finished surface. Along the edges of the road care is taken to provide a good shoulder to hold the pavement in place. Where the soil is soft, stone is added and the shoulder rolled.

Where the old macadam is flat or depressed at the center, the sides are picked up and the material moved to the center. Care is taken not to lower the sides so that there will be less than 4 in. of stone in a firm condition. Where the condition is such that additional material is required, the street is scarified to a depth of 3 in. and material added to make the depth at least 10 in. at the middle and 6 in. at the sides. About 2½ in. fall from the crown to the side is sufficient for drainage.

This work is paid for out of the city wheel-tax, which is imposed on all vehicles for the purpose of providing a fund for road repairing. The description given above is compiled from information furnished by Walter G. Leininger, Superintendent of Streets of Ch ago.

FIG. 2. IMPROVING COUNTRY ROADS WITHIN THE CITY LIMITS OF CHICAGO

(The view at the left shows the 2-in. top course of asphaltic concrete being laid and rolled. The view on the right shows the old road receiving a course of macadam to level it up for the asphaltic-concrete top course.)

Headquarters Inspection Division of the New York State Highway Department

The many difficulties which were experienced in connection with the final inspection and acceptance of roads after they had been completed by the contractor have led George A. Ricker, First Deputy State Highway Commissioner of New York, to devise and install a new method of inspection by a headquarters corps of inspectors, which has proved efficient and beneficial in all respects. The function of these inspectors is almost entirely critical; they give no orders and are careful even about offering advice unless it is asked for by the engineers in charge of the roads which they are inspecting. They are all high-class, experienced and well paid engineers.

Mr. Ricker's scheme consists in having a number of these inspecting engineers, reporting to and solely responsible to him, continually engaged from the beginning to the end of the working season in making field inspections. There are seven of these inspectors for the nine highway divisions of the state. Each inspector makes the rounds of his territory in about 20 days, visiting and reporting upon every piece of construction work during that period. They report regularly the extent and character of the work done to date not only by the contractor's but by the state's engineers.

After studying these reports, the Deputy Highway Commissioner takes up with the division engineers any points which may be necessary. These points of criticism are communicated by the division engineers to the engineers in immediate charge of the work in a filled-out form letter, with a request for explanations and constructive criticism. The reply is made on the back of this letter, and this and the inspector's report are fastened together and filed.

As noted, there is a report on each road on an average of once in 20 days. When the contracts are completed the headquarter's office files contain a complete and detailed history of each road, with complete information regarding it and not a mere superficial report of surface conditions after the road is completed. This not only greatly facilitates final acceptance of the road from the contractor, but avoids, or brings out at the time they are made, mistakes and deviations from the contract specifications which would hinder final settlement.

Although not at first looked upon with approbation by the contractors, this system of inspection soon proved of so much value to them and division engineers as well as to the First Deputy Commissioner, who is practically the chief engineer of the highway department, that it is now recognized as a very useful and satisfactory adjunct of the department. The scheme has passed the experimental stage and is a regular feature of the organization.

Reconstruction of Pogues Run at Indianapolis

A costly piece of sewer work which has just been commenced at Indianapolis, and is an important preliminary to the extension of track elevation through the union station, is the reconstruction of the Pogues Run drain for a distance of about 2½ miles. This is an old creek now forming an open sewer, which flows approximately southwest across the city and discharges into White River. Its normal dry-weather flow is about 5 cu.ft. per sec., but

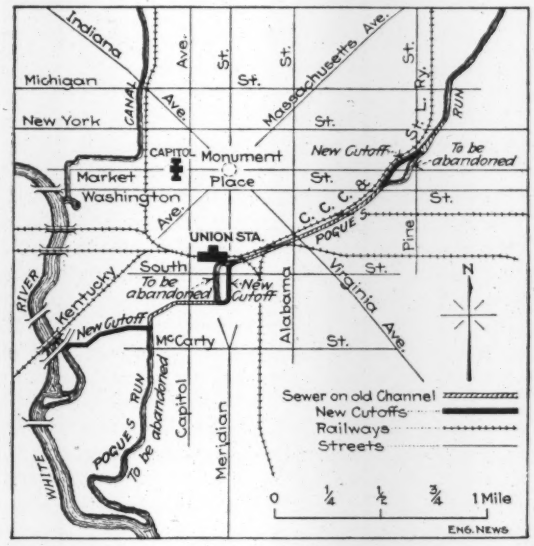


FIG. 1. PLAN OF THE NEW COVERED CHANNEL FOR POGUES RUN AT INDIANAPOLIS, IND.

in times of freshets and heavy rains it may have a flow of 3000 cu.ft. per sec.

For a length of about 5100 ft. through the railway yards and terminals the creek is lined with masonry walls 36 ft. apart, and is spanned at some points by plate-girders which carry signal cabins and similar structures. The creek closely follows one of the railway lines and as it crosses the site of the union station and terminal yards the city must replace the present open channel by a covered channel. This will mainly follow the present route, but between New York and Washington St., a bend will be avoided, and near the station there will be a new line along Meridian St. There will be also a new outfall, giving a direct line to the river instead of the present winding course. These diversions are shown on the map, Fig. 1.

The grade in general is 0.15% and 0.20%, but there is a short fall of 0.5% from Washington St., while at the outfall the grade is 0.7%. The sharpest curves are of 100-ft. radius. Beyond the portal will be a 30-in. reinforced-concrete apron on piles, with wing walls. This will be 25 ft. long, with a width (between wing walls) of 39 ft. 2 in. at the portal and 51 ft. 2 in. at the lower end.

The new conduit will be of reinforced concrete, and will be of very exceptional size and construction, consisting of two rectangular channels, as shown by the typical section, Fig. 2. At the upper end these will be 16 ft. wide and 8 ft. high, but mainly they will be 18x8 ft., while for a portion of the lower end and at the portal the width is increased to 19 ft. The two channels are to be connected at intervals of 100 ft. by openings 6x5 ft. in the center wall. The depth of fill over the roof will be from 4 to 20 ft., and at some points the conduit walls will have to carry the columns of street bridges (over the tracks) and of the station structures.

The side walls will be 18 and 20 in. thick and the central wall 18 in. The top and bottom slabs are mainly 21 to 24 in. thick, but at certain points these are increased to 32 in. for the top and 30 for the bottom.

The arrangement of the reinforcing steel is shown in Fig. 2. It will consist of deformed bars. In construction, the bottom and walls will be built first, and then the roof, with a mortised joint along the tops of the side walls, as shown. The concrete will be 1:2½:5 for the lower portion and 1:2:4 for the top, using gravel for the aggregate. The construction will be attended with some difficulty, especially where the drain passes under the tracks and adjacent to large buildings, which will have to be shored up while the foundations are being underpinned.

This work was approved by the Board of Public Works in April, and in June the contract was let to Dunn & McCarthy, of Chicago, at $907,000. In addition to this cost, there will be the expense of supporting buildings during construction, and this is estimated to cost about $31,000. The work is under the direction of B. J. T. Jeup, City Engineer, and D. C. Hayne, Assistant Engineer.

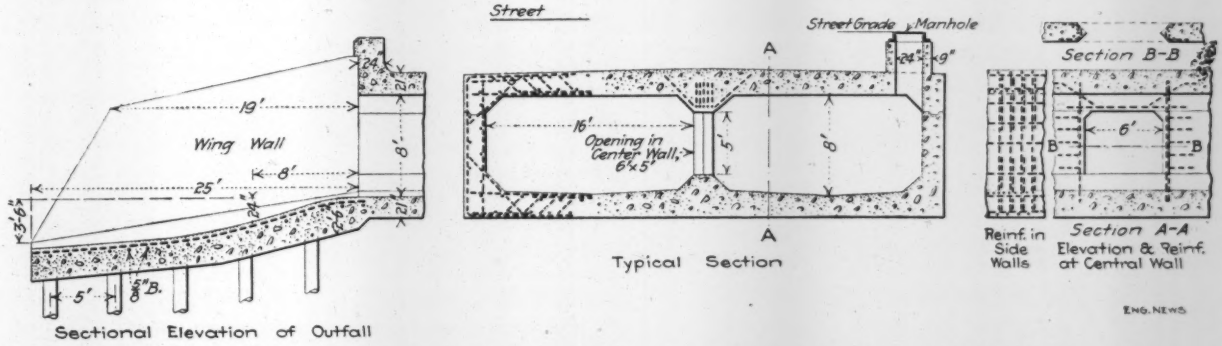


FIG. 2. DOUBLE-BARREL CONDUIT TO REPLACE THE PRESENT OPEN CHANNEL AT POGUES RUN AT INDIANAPOLIS, IND.

Field and Office

Construction Plant Layout for New Filtration Plant at Cleveland, Ohio

Work on the new filtration plant for the Cleveland water-works system, which is to be located near the lake front between West 29th St. and West 38th St., is progressing very rapidly. The exceptional speed with which the work is being done is due in no little degree to the very well laid-out construction plant which the contractor, John F. Casey Co., has installed and is operating.

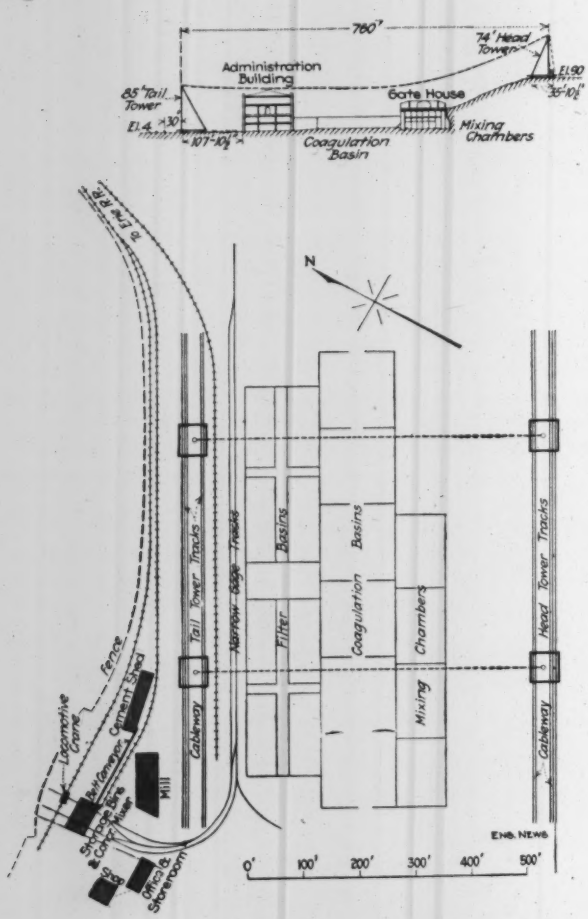


FIG. 1. PLAN AND SECTION OF CONSTRUCTION PLANT ON NEW FILTRATION PLANT AT CLEVELAND, O.

The filter plant is on what was a side hill running down in about 900 ft. from an elevation of 90 ft. to an elevation of only 4 ft. above lake level at the north or lake side of the site. The dimensions are 1200 ft. running east and west parallel to the lake and 900 ft. north and south. Previous to the letting of the contract, the city excavated to near the grade most of the area covered by the various basins of the plant and turned the site over to the contractor in this shape, except for one section at the southeast end of the plant where extensive steam-shovel excavations had to be made later.

The topography of the site lent itself admirably to the cableway installation shown in Fig. 1. Briefly, the layout consists of a concrete-mixing plant accessible from main-line railroad sidings and dumping over narrow-gage tracks running out under two cableway spans, the towers of which travel parallel to the long dimension of the filtration plant and control the narrow-gage track and a main-line siding, and the entire field of construction operations.

The method of carrying on the work can be traced to better advantage by examination of the plan in Fig. 1. The tracks of the Erie R.R. enter the fenced-in site from the northeast. Sand and gravel are brought in on a siding from the main line and carried up on the trestle and dumped into open bins just north of the concrete mixer. From these open bins the gravel and sand are lifted by a locomotive crane traveling on the trestle into storage bins in the top story of the mixing plant. Cement is brought in over the same track and is normally delivered in such quantity that the cement can be loaded directly from the cars in sacks onto the belt conveyor, which is shown leading into the mixing plant where it is stored on the same floor as the top mixing hopper. When a surplus of cement arrives, it is stored in the cement shed shown just east of the mixing plant. All other material is brought in on the main-line track just south of the cement track and is stored in various parts of the yard where convenient.

A mill is placed just near the stub end of this track and another track runs around to the north of the mixing plant, so that it is convenient to the machine shop located there. The cableway tracks, each consisting of three rails to carry the usual pyramidal tower, run in an easterly and westerly direction, one on the lower level north of the work and the other on the upper level, some 90 ft. higher along the top of the original bank and entirely south of the work. The head tower is 74 ft. high and the tail tower 85 ft. high, while the span is 760 ft. There are two cableways provided, each of a capacity of 15 tons and each with its own hoisting-engine equipment. Another main-line stub end runs directly under the cableway span, by which material can be picked directly off the main-line cars and conveyed to whatever part of the work it is required.

For concreting there is a duplicate equipment of Hains mixers of a design improved by Ottomar Stange, a member of the contracting firm which is doing the work, but so far it has been necessary to use only one of the mixers to take care of all the concreting which has been needed. The Hains mixer is of the gravity type, which requires no power. It consists of a series of approximately conical buckets placed one above the other, into the top one of which the various ingredients making up the concrete are dumped and receive the mixing action by turning over through the cones. As shown in Fig. 3, the sand and

FIG. 2. LOOKING SOUTHWESTERLY OVER CONSTRUCTION PLANT AT CLEVELAND FILTRATION PLANT
(Upper cableway tower on left; lower towers on right. Concrete plant in background.)

gravel are stored on the top floor of the mixer house and can be dumped into the top hopper by merely throwing a gate. Proper measurement is made by marks on the side of the top hopper bucket, which can accommodate about 4 cu.yd. Cement is dumped from the hopper floor where the sacks are stored. Water is led in from a pipe delivering to the top of the hopper.

Concrete is delivered through the bottom hopper into the bottom dumping bucket of a conical shape somewhat similar in design to the individual bucket in the concrete mixer. These buckets have a capacity of 5 cu.yd., so that they are never overflowed by the delivery of one batch from the mixer. They are loaded on narrow-gage cars drawn by steam dinkeys and carried out under the cableway, where the buckets are picked up and swung out over the particular part of the work where they are required. The capacity of this plant is from 1200 to 2000 cu.yd. per day, but so great a capacity has never been required because of the difficulty of finding that much concreting to do in a work which consists of so many articulated small members.

Forms for the various parts of the work are standardized and have been, as a rule, used about four times for each form. About 1500 men are employed on the job.

The work is being done under the direction of the City of Cleveland, with C. W. Schulz, Commissioner of Water, and R. Winthrop Pratt, Consulting Engineer, F. H. Stephenson, Designing Engineer and R. S. Jones, Engineer of Construction, by the John F. Casey Co., of Pittsburgh and Cleveland. Ottomar Stange, of the firm, is in direct supervision of the work, and C. H. McAlister the Cleveland manager. E. J. Gass is chief engineer of the Casey Company, and D. F. Davison, superintendent on the work.

Proposed Standard Abrasion Test for Gravel*

The gravel is first screened through screens having circular openings 2 in., 1 in. and ½ in. in diameter. The sizes used for the test are equally divided between those passing the 2-in. and retained on the 1-in. screen, and those passing the 1-in. and retained on the ½-in. screen. The material of these sizes is washed and dried. The following weights of the dried stone are then taken: 2500 grams of the size passing the 2-in. and retained on the 1-in. screen and 2500 grams of the size passing the 1-in. and retained on the ½-in. screen. This material is placed in the cast-iron cylinder of the Deval machine as specified for the standard abrasion test of broken stone for road-metal.

Briefly described, this machine consists of a frame and two or more cylinders mounted at an angle of 30° with the axis of rotation. The cylinders are of the following size: 20 cm. diameter x 34 cm. deep, inside dimensions. Six cast-iron spheres 1.875 in. in diameter and weighing approximately 0.95 lb. (0.43 kg.) each are placed in the

*Result of an investigation conducted by the Bureau of Tests of the Ohio State Highway Department; published in full in the Ohio State Highway Department Monthly for August, 1914.

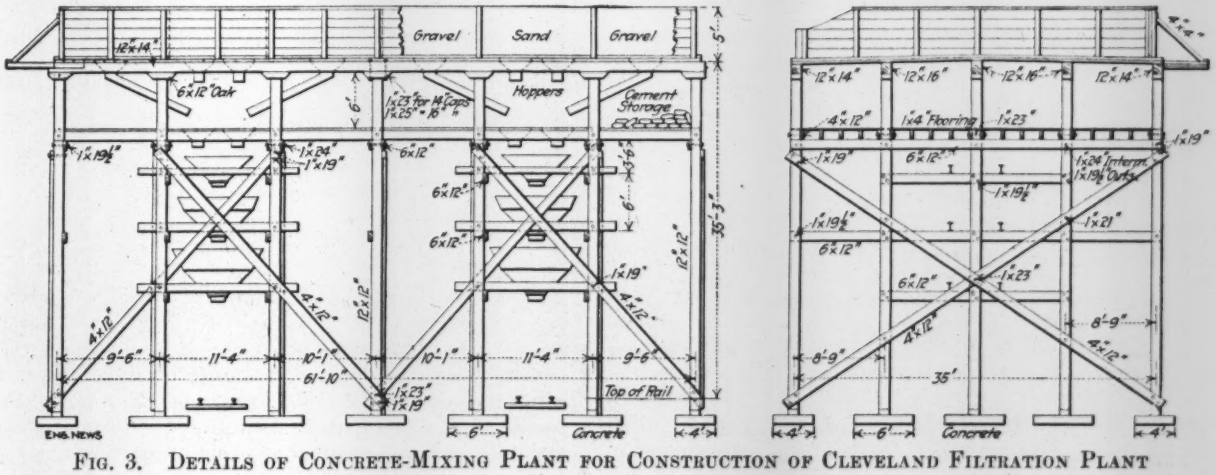


FIG. 3. DETAILS OF CONCRETE-MIXING PLANT FOR CONSTRUCTION OF CLEVELAND FILTRATION PLANT

cylinder as an abrasive charge. The iron composing these spheres, which are the same as those used in the standard paving-brick rattler test, have the following limits of composition:

Combined carbon	Not under 2.50%
Graphite carbon	Not over 0.25%
Silicon	Not over 1.00%
Manganese	Not over 0.50%
Phosphorus	Not over 0.25%
Sulphur	Not over 0.08%

After the cast-iron spheres have been placed in the cylinder the lid is bolted on and the cylinder mounted in the frame of the Deval machine. The duration of the test and the rate of rotation are the same as specified for the standard test for stone, namely, 10,000 revolutions at a rate of 30 to 33 r.p.m.

At the completion of the test the material is taken out and screened through a No. 16 mesh screen. The ma-

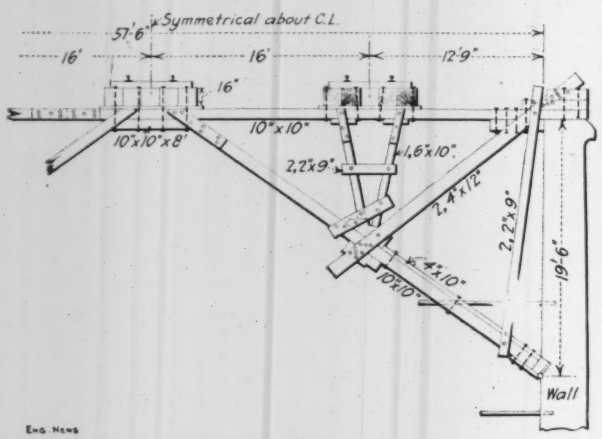


FIG. 1. TYPICAL TRUSS FOR SUPPORTING WORK TRAINS ON EASTERN VIADUCT

terial retained upon this screen is washed and dried and the per cent. loss by abrasion of the material passing the No. 16 screen calculated.

As a means of comparing the results obtained from this test with those from the standard stone test, a series of tests were made using the rounded, or abraded, stone from the latter test, but of the sizes and proportions adopted for the gravel test. In order to obtain a sufficient quantity of the smaller size, it was necessary to break up an additional amount of stone and subject it to the abrasion test, until all the corners and edges were rounded off.

The advantage of this test over the standard stone test for coarse gravel, aside from the consideration of the size of material, is the increased severity of the abrasion on the soft friable sandstone pebbles and material of a similar nature. In this test the impact of the cast-iron spheres breaks up the soft pebbles, while in the stone test the impact of the stone on stone merely tends to round off the corners and edges.

As the purpose of this test was primarily to indicate the presence of material having a low resistance to wear it is believed that it will be of special value when applied to gravel to be used in concrete which is subjected to wear or abrasion, as well as to gravel for road surfacing.

The use of gravel for both purposes is constantly increasing and the development and preparation of the material has become an important industry.

Pneumatic Tampers on an Unusual Earth-Filling Job

A most interesting earth-filling job is under way at the Eastern Viaduct of the New York Connecting R.R., Astoria, L. I. The structure is part four-track steel viaduct and part a retaining-wall structure with earth filling. The earth fill work in the latter portion involves several novel features, the most important of which is the use of power tampers.

Work trains bring the earth to the top of the viaduct and dump it between the retaining-walls in four windrows. It is then spread to a 12-in. layer and tamped to a crown (slopes of ¼ in. per ft.). The tampers are of the hand-manipulated pneumatic type, illustrated by Fig. 2, as furnished by the Ingersoll-Rand Co. for foundries. A maximum of 10 tampers has been in operation simultaneously on this job, although 20 are at hand.

The viaduct is of unusual construction. Thin reinforced-concrete walls stiffened by tie-rods and cross-walls retain the fill, which is tamped and drained to secure the minimum pressure. The side walls vary from 35 to 70 ft. in height and are 3 ft. thick at the top, with stepped footings 6 ft. wide at the base. They contain no expansion joints. The right-of-way here is quite expensive, which makes an embankment too costly. The concrete viaduct was chosen because it was less expensive than steel.

DESCRIPTION OF THE WORK

The fill, which is a mixture of sand, gravel and loam, is obtained free from the Sunnyside yards of the Pennsylvania R.R., about 3½ mi. distant from the site. A steam shovel of 2½-cu.yd. capacity loads the earth on dump cars coupled in 11-car trains drawn by an 18-ton

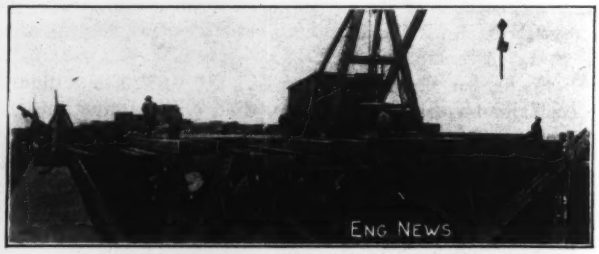


FIG. 2. TRAVELING DERRICK SETTING FALSEWORK ON VIADUCT

dinkey engine. The cars are rated at about 3.8 cu.yd. each, and from 250 to 300 cars are handled per day. The loaded trains go up on the viaduct by means of trestling. The tracks are carried on transverse timber trusses resting on the side walls of the viaduct, as sketched in Fig. 1. When a bay is filled, the switch tracks and truss caps are removed; the remainder of the truss is left buried in the fill.

That the tamping to a crown may be reasonably accurate, the inspector for the railway marks on the wall the lines to be followed by the tampers. Measurements are taken from the transverse tie-rods, between side walls. These tie-rods are an obstacle to rapid tamping, as, whenever they are encountered, tamping must be suspended while the rods are incased in concrete. The tie-rods are spaced 10 ft. apart both in vertical and horizontal planes. In placing, they are fitted to stubs projecting from the

FIG. 3. "CROWN" POWER TAMPERS AT WORK NEAR AN ARCH RIB

FIG. 4. SHOWING TAMPED SURFACE

side walls, by means of turnbuckles. The rods are placed when the tamping has reached a position 4 or 5 ft. below the stubs. When the fill has reached the rods, wood forms are placed around them and filled with 1:6 concrete, which is permitted to set for 24 to 48 hours, depending on the weather.

The first section of the work was completed Aug. 15; about 14,000 cu.yd. of fill were placed. During the work on this section, other parts of the fill were in progress. The total fill will amount to about 200,000 cu.yd., distributed over a distance of about ¾ mi.

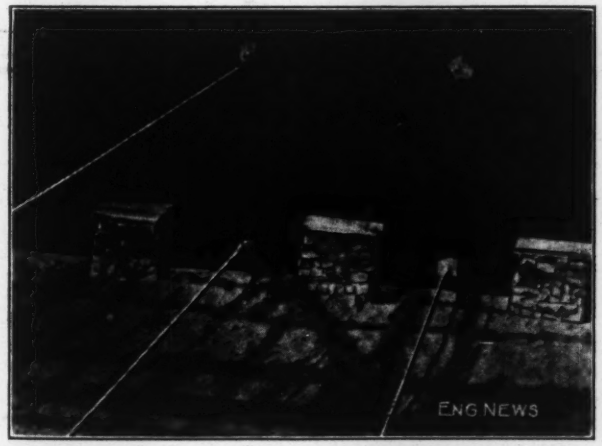


FIG. 5. SHOWING RUBBLE DRAINAGE CHIMNEYS AND TIE RODS

Chimneys (2x3 ft. in plan) rise from weep-holes at bottom of sidewalls, to top of fill. View shows tie rods ready for concrete forms.

Air for the tampers is supplied from a compressor rated at 946 cu.ft. of free air per min., 100 lb. per sq.in. pressure, driven by a 150-hp. motor. The plant is located at Potter Ave., whence a 3-in. air line extends westward to the East River, a distance of 1400 ft. The last several hundred feet of line are reduced to a diameter of 2 in. Another air line runs eastward along the viaduct a distance of 2100 ft. The 1-in. air hose of the tampers is connected to a 10-part manifold. One of these manifolds is provided in each bay in which tamping is in progress.

An interesting feature of the fill is the rubble-chimney construction which rises from weep-holes in the lower part of the viaduct wall for draining the bays. Rock packing is also placed between stiffening ribs of abutments and part way up the rear of the street arches. This chimney construction is illustrated in Fig. 5.

Number of Men—The steam-shovel gang at Sunnyside comprises an engineer, fireman and craneman. There are six men in the pit gang. Each of the five trains in operation carries an engineer and a brakeman. Five laborers and a foreman dump the material from the top of the viaduct. Below in the bays, there are 45 laborers, two foremen, and six tampers. The concreting of the tie-rods is done by 12 laborers and a foreman. The fill proceeds at the rate of about 2 ft. vertical per day. Two machinists are employed to insure the smooth operation of the tampers.

Personnel—The work is being done for the New York Connecting Ry. (G. Lindenthal, Consulting and Chief Engineer) by Holbrook, Cabot & Rollins, New York City. The work is carried on by the contractor under the direction of T. B. Bryson. The superintendent at the site is Wyllys Russell.

A Fractured Pipe Casting on the Catskill Aqueduct That Sealed Itself in Service

By A. W. Tidd*

A manhole casting, one of several large special pieces inserted on the line of the Catskill Aqueduct in the Bryn Mawr connection chamber—the point of junction between the Bryn Mawr steel-pipe siphon and the Yonkers pressure tunnel—recently cracked and sealed itself in peculiar fashion. The casting did not fail completely, the crack being about 3 ft. long with an opening midway of its length of 1/8 in. The casting was under pressure from water impounded for a hydrostatic test of the Yonkers pressure tunnel. The leakage was considerable at first but, as time went on, the flow slackened and at last ceased altogether, due to deposition in the crack of a hard, white substance that finally completely filled the opening.

Fig. 1. The Fractured Manhole Casting in the Bryn Mawr Connection Chamber

(Looking down on dome; the crack is under the tunnel lamp.)

The details of the design and construction of the work in this vicinity were given in an article in Engineering News, Sept. 24, 1914. The casting is roughly 6 ft. in diameter, 7 ft. 3 in. long, 2¼ in. thick. It weighs 14,700 lb., and has a manhole on the top 3 ft. in diameter.

The crack extended to both flanges (see sketch) but did not pass through either. It was fairly straight, passing practically radially through the shell. The maximum opening occurred on the horizontal part of the pipe next to the manhole. The cause of the fracture cannot be settled definitely as the casting is still in place.

The tunnel was being filled to elevation 295, the hydraulic grade (by pumping from a near-by stream), in order to make a test under conditions representing those of actual service. The elevation of the casting is 127.5, the head on the casting in service being thus about 168 ft. The fracture occurred probably between 5 and 6 a.m., Jan. 8, 1914. No one was present; it was discovered at 8 o'clock. As determined from evidences on the walls of the uptake shaft at Hill View reservoir, the water had reached elevation 227.9 when the fracture occurred. Pumping was discontinued and no attempt was made to stop the escaping flow, which at that time was gaged at about 138 gal. per min. After a couple of weeks, it was noticed that the flow was diminishing. After a month had elapsed, the leakage amounted to less than 4 gal. per min., and in two months had ceased entirely even with the head restored to within a few feet of that at which the break occurred.

The following table gives the leakage and the corresponding elevation of the water in the tunnel. The curious fluctuations of the water level were due to a continuous leakage into the tunnel, which gradually exceeded the outward leakage at the crack. As soon, however, as the rising water reached the elevation at which the casting cracked the level was ordered drawn down by opening valves in the connection chamber. This drawing down was done several times.

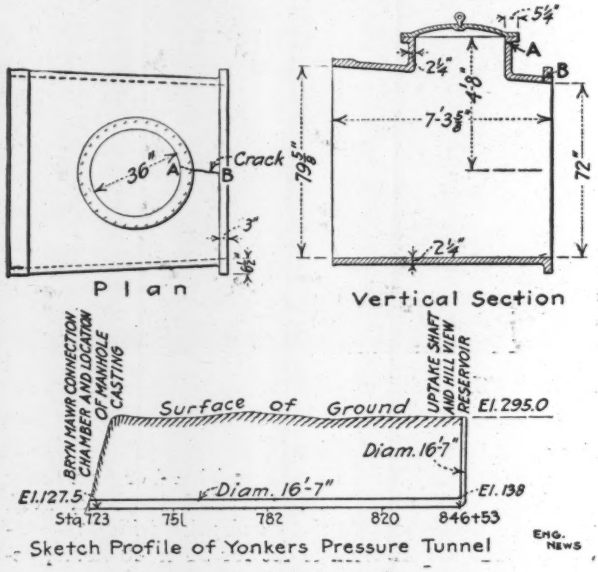


Fig. 2. Sketches of Fractured Manhole Casting and Yonkers Pressure Tunnel Profile

Date 1914	Elevation of Water	Leakage through Crack Gal. per Min.
Jan. 8	227.9	(Fracture occurred)
Jan. 8	222.8	138 approximate
Jan. 19	180.3	42
Jan. 23	149.6	17
Jan. 28	150.0	14
Jan. 30	150.2	10
Feb. 2	150.5	9
Feb. 10	151.8	0.2
Feb. 17	171.1	0.2
Feb. 21	218.0	0.3
Feb. 26	154.0	0.3
Mar. 1	204.4	0.2
Mar. 2	152.6	0.2
Mar. 4	165.5	0.0
Mar. 10	223.6	0.0

In order to avoid the delays due to the replacing of the fractured casting, it was banded with 1-in. rods, as shown in the figure, five on the main portion and four on the dome, with a strip of soft sheet lead about ½ in. thick and 2 ft. wide laid over the crack. The bands were put on Mar. 10, and the water raised to the hydraulic grade Mar. 15. Twice after that date, on Mar. 18 and 20, the water was raised again to the hydraulic grade. No leakage occurred nor weakness developed, and

* Senior Section Engineer, Board of Water Supply, City of New York; 215 Kimball Ave., Yonkers, N. Y.

the hydrostatic test was completed without further incident.

The hard, white substance that was deposited on the casting near the crack and wherever the spurting water struck was analyzed with the following results:

Silica, SiO_2	5.58	Magnesia, Mg O	.56
Oxide of Iron, Fe_2O_3	1.30	Sulphuric Anhydride, SO_3	.44
Alumina, Al_2O_3	0.24	Carbon dioxide, CO_2	41.15
Lime, CaO	50.73		

The deposited material was chiefly carbonate of lime.

In April, after the tunnel was unwatered, a flocculent deposit was found to have collected along the entire length of the invert. Samples were taken near the manhole casting and at Stations 751, 782 and 820; the results of their analyses follow:

	Near Casting	Sta. 751	Sta. 782	Sta. 820
Silica, SiO_2, and insoluble silicates	*52.36	6.51	3.46	3.53
Oxide of Iron, Fe_2O_3	7.70	1.26	0.71	0.56
Alumina, Al_2O_3	5.04	4.31	2.12	0.71
Lime, CaO	10.62	40.02	47.19	48.97
Magnesia, MgO	1.53	5.18	3.19	4.10
Sulphuric Anhydride, SO_3	0.27	0.32	0.21	0.18
Carbon dioxide, CO_2	9.43	39.28	41.64	41.25
Organic and volatile matter	13.05	3.12	1.48	0.70

*Chiefly silt.

The silt is accounted for by the water for filling the tunnel up to the time of the fracture being pumped from a near-by stream. The lime was, of course, produced wherever there was percolation of ground water through the concrete tunnel lining.

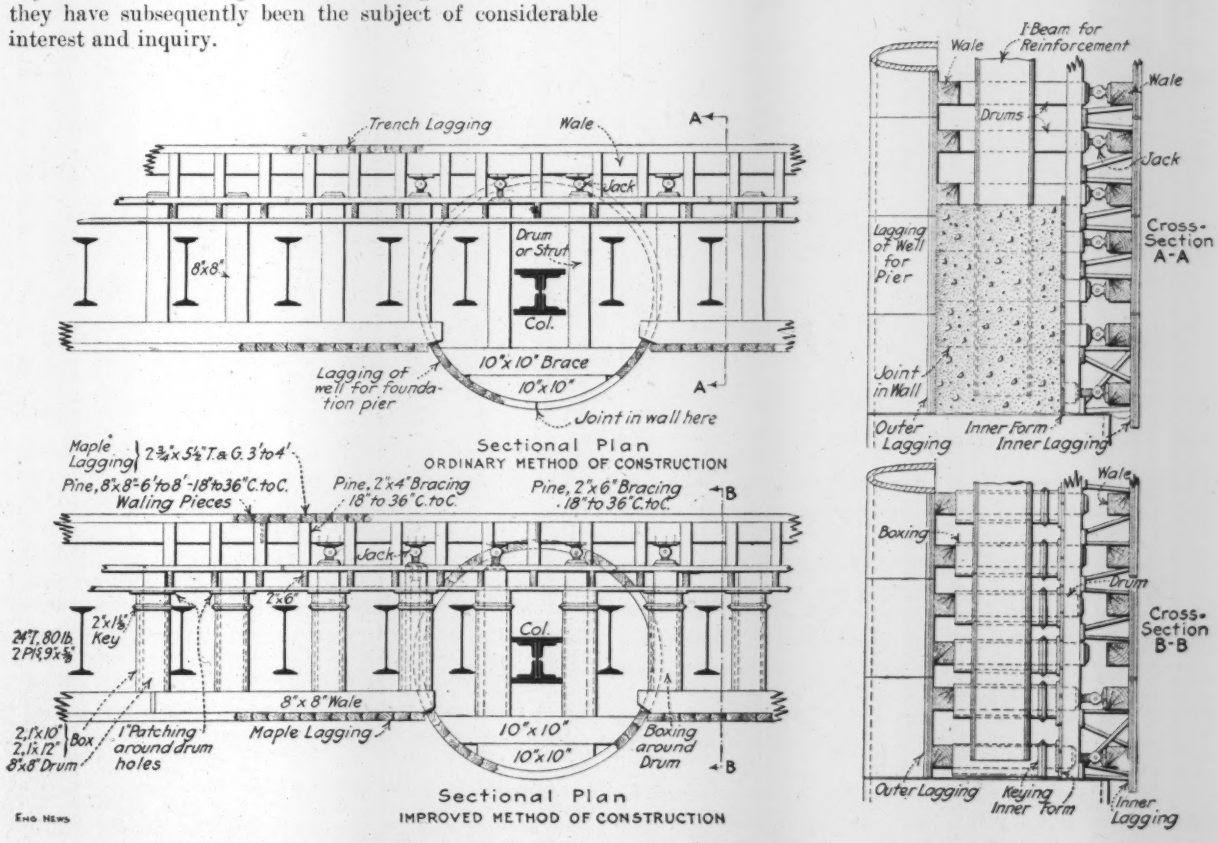
These disconnected details have been collected in this one article because, although each was a part of the day's work and not given much thought at the time, they have subsequently been the subject of considerable interest and inquiry.

Construction of Retaining Walls for Deep Basements in Clay Ground

In many of the large new office buildings in Chicago, having foundation piers sunk through the clay bed to rock, a portion of the area is excavated for two or three (or even four) basement floors. These excavations must be surrounded by heavy retaining walls to resist the pressure of the clay. The walls are built in trenches excavated to the required depth, lined with sheeting against which are placed waling timbers, braced by cross timbers or "drums" having a jack screw or trench brace between one end of the drum and the waling timber.

Ordinary Method of Construction

Under the ordinary method of building the wall, the forms are placed in position in the trench thus braced, and then concrete is deposited up to the level of the bottom of the first row of drums. This layer of concrete is allowed to set or harden for 12 to 24 hours. New drums are then placed behind the concrete-filled portion of the form. Then the drums and jacks of the row above the concrete are removed, after which the forms are set for the next course and another layer of concrete is deposited to fill to the level of the next row of drums. This is indicated by the horizontal dotted lines in the upper drawing of the accompanying cut, and the operations are continued successively until the top of the wall is reached.



Methods of Constructing Retaining Walls for Deep Basements in Clay Soil at Chicago

The upper drawing shows the method ordinarily used. The lower drawing shows the improved method employed by Holabird & Roche on the new Lumber Exchange Building.

The outer lagging is left in place, but the outer waling timbers are removed at the same time as the drums.

This method has several disadvantages, one of them being the slow rate of progress on work where rapid construction is usually most desirable. Then, the walls are not monolithic, but are composed of a series of separate horizontal courses, and although these are united by keys or ribs, the arrangement is not well adapted to resist heavy lateral pressure. Certain floor panels in the floors above must be left open to allow of placing a reinforcement of vertical steel beams, as it is not satisfactory to use steel-rod reinforcement, owing to the large number of horizontal joints and the difficulty of taking care of shear. The pressure of the earth also has to be resisted by the green concrete, which in many cases is displaced or distorted to some extent. This allows a movement of the clay body which may affect adjacent buildings.

New Method of Construction

In the construction of the Lumber Exchange Building, at La Salle and Madison Sts., a new method was adopted for building the sub-basement retaining walls, the lower sub-basement floor being about 50 ft. below the street. The trenches were excavated in alternate sections, the joints being at the centers of the columns. They were 6 ft. wide, and sunk in 3-ft. lifts, each lift sheeted with 3x6-in. vertical lagging and two lines of 8x8-in. horizontal waling. The 8x8-in. drums were then placed between the waling timbers and made as tight as possible by the screws. This process was continued lengthwise in 6-ft. sections along the trench, and then downward to the desired elevation.

After the excavation of the trench was completed about 6 in. of concrete was deposited for a working floor and forms were built for the full height of the wall. The forms were cut away around the drums, which were boxed in or cased with 1-in. lumber; ribs on the boxing formed grooves or keys for bonding with the concrete filling later.

Then the trench was concreted from base to top in one operation, thus giving a homogeneous or monolithic wall, which was allowed to set for about two weeks, the pressure of the earth during that time being resisted by the drums or struts and not by the forms and concrete as in the other method described. The outer waling and lagging are left in place. When the basement is excavated the inner lagging is removed, the drums are pulled out of their boxing, and the inner form and boxes taken down. The holes left by the boxes are then filled with a dry concrete, well rammed, which is held in place by the notches or grooves formed by the keys. This method is shown in the lower drawing.

The advantages of this method are that the work progresses much more rapidly and gives a monolithic construction, while it eliminates the objection to rod reinforcement in these walls (though in this case some of the walls contain I-beam reinforcement). Another important advantage is that the drums take up the pressure, and relieve the wall of all pressure until the concrete has become thoroughly set and hard.

The building in question is a 16-story office building about 135x101 ft., 200 ft. high above the street and with its sub-basement (for boiler room) 50 ft. below the street. The prevention of any movement of the clay bed was very important, since the 16-story Y. M. C. A. building with floating or grillage foundations adjoins the south side of the site, while the 13-story Tacoma Building, also with float foundations, is across the street, and an old 3-story building with surface foundation is adjacent.

The architects are Holabird & Roche, of Chicago, and the new method of basement wall construction was devised by them. The George A. Fuller Co. is the general contractor. The structural steel was furnished by the American Bridge Co., and erected by the Oscar Daniels Co., while the shoring was done by the Ruud-Neilson Co.

Commissary Supplies on a Canadian Survey

The question of commissary supplies for field parties is always of interest. We give herewith a table of the quantity and cost per man per day at a main camp for survey work on the Abitibi River, in the northern part of Ontario, in the winter of 1913. It is taken from a paper on "Contour Surveys on the Abitibi River," by H. T. Routly, in the annual report of the Association of Ontario Land Surveyors, at Toronto. The average number of men boarded was 18, including the cook. In a brief comment upon this list Mr. Routly says:

"We have always believed in feeding our men what they liked, within reasonable limits, and it is interesting to note the difference in requisitions of different parties.

CONSUMPTION OF FOOD AND SUPPLIES BY A CANADIAN SURVEY PARTY

(The figures are the amount per man per day.)

Supplies	Quantity per day	Cost per day, cents	Supplies	Quantity per day	Cost per day, cents
Apples	.035 lb.	.341	Matches	.006 box	.075
Apricots	.025 lb.	.435	Onions	.005 lb.	.199
Bacon Br.	.215 lb.	5.436	Peaches	.025 lb.	.300
Bacon L. C.	.475 lb.	7.485	Peas	.049 lb.	.195
Bacon pickled	.022 lb.	.315	Pepper	.007 lb.	.100
Bak'g powder	.010 lb.	.165	Pickles	.002 gal.	.200
Barley	.005 lb.	.017	Potatoes	.525 lb.	.662
Beans	.120 lb.	.657	Potatoes, desic.	.028 can	2.590
Butter	.154 lb.	5.217	Prunes	.050 lb.	.362
Beef	.813 lb.	8.628	Raisins	.077 lb.	.581
Candles	.378 candle	.752	Rice	.037 lb.	.176
Cheese	.062 lb.	.880	Rolled oats	.055 lb.	.179
Coal oil	.003 gal.	.077	Salt	.021 lb.	.088
Cocoanut	.002 lb.	.067	Soap	.041 cake	.188
Coffee	.017 lb.	.490	Spice	...	.062
Corn	.064 can	.642	Sugar, brown.	.178 lb.	.967
Corn flakes	.098 lb.	.862	Sugar, gran.	.265 lb.	1.398
Cornstarch	.004 pkg.	.026	Syrup	.007 gal.	.595
Cream	.200 can	3.172	Tea	.036 lb.	.848
Currants	.052 lb.	.284	Tomatoes	.073 can	.820
Flavoring	...	.280	Turnips	.075 lb.	.055
Flour	.825 lb.	2.945	Yeast cakes	.007 box	.031
Jam	.015 lb.	.112			
Lard	.092 lb.	1.815			
Macaroni	.115 lb.	.032			
					51.797

The above table is simply an analysis of actual quantities and costs on this particular contract. A change of cooks will often make a great difference in the comparative amounts of various items used.

"In most of our northern work we used desiccated potatoes, but on this contract some of the ordinary tubers were used. These were frozen solid coming in, and it may be of interest to note that the best method of preparing frozen potatoes is not to thaw them with cold water, as is usually done, but to brush them clean, give them a quick rinse with hot water, plunge them at once into a pot of boiling water, and cook them with jackets on."

Crowns for Road Surfaces—The committee on roads and pavements of the Ohio Engineering Society recommends the following average crowns per foot for various kinds of road surfaces:

Earth, 1 in.; waterbound macadam, ⅝ in.; bituminous macadam, ½ in.; brick, ⅜ in.; concrete, ⅜ in.; asphalt, ⅜ in.; wood block, ¼ in.

NOTES

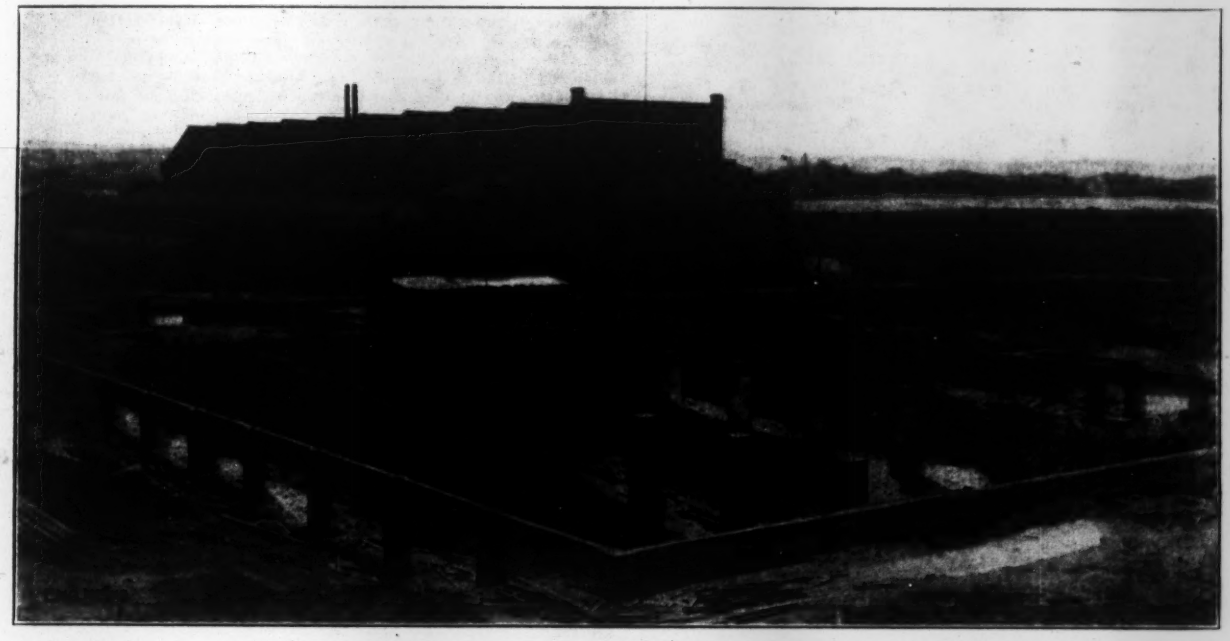
The Conventional Signs for Plans and Drawings compiled and adopted by the American Railway Engineering Association have been specified by the Valuation Board of the Interstate Commerce Commission for use on all maps and profiles employed in the railway valuation work now in progress. These conventional signs are now printed in pamphlet form (6x9 in.), with 12 pages relating to various signs for general maps, profiles and drawings, one page relating to riveted work and 12 pages relating to signal and electrical work (as adopted also by the Railway Signal Association). Several railways are ordering these pamphlets in large numbers for their engineering and drafting departments. Copies may be obtained from E. H. Fritch, Secretary of the Railway Engineering Association, 900 South Michigan Ave., Chicago. The price is 25c., but lower prices are made on orders for 10 or more copies.

Wall Girders in a Machine Shop Building—The walls of a new shop being built for the Ball Engine Co. at Erie, Penn., are carried in part by direct footings and in part by wall girders. This unusual combination is shown quite clearly by the adjoining photographs. It was due mainly to the conditions of the subsoil.

The site was formerly a gravel pit, which had been excavated to an average depth of 12 ft. below grade and later partly refilled with foundry waste. This refill was not suited to carrying the column piers or the wall footings. The column piers were therefore carried down to the original bottom, which makes some of the large center piers 16 ft. high. At the rear wall the firm ground was near enough to permit of direct footings of relatively shallow depth, and the heavy weight of the front wall required continuous footings to be used here also. The side walls, however, carry only a 6-ft. height of 8-in. hollow-tile curtain-wall, and as they come over the deep part of the former gravel pit, a reinforced-concrete girder construction was employed to carry these walls, as shown. The space under these girders will be filled with earth.

The building is 150 by 200 ft., of steel frame and hollow-tile walls. The front and rear walls are respectively 16 and 12 in. thick, the side walls 8 in. The girders under the side walls are 12x36 in. by 20 ft. long, the spacing of column piers.

In constructing the foundation, two cuts were made through the waste refill with a steam shovel, to build the center piers. After completion, the whole was filled to grade. Constable Bros., of Erie, Penn., were the contractors. H. Edsil Barr, of Erie, Penn., acting as engineer for the owners, designed the construction.



FOUNDATION OF NEW BALL ENGINE CO. SHOP, ERIE, PENN.; WALL GIRDERS FOR SIDE WALLS, DIRECT FOOTINGS FOR FRONT AND REAR WALLS

The Novelty in Stadia Methods devised by J. Zwicky, of St. Gallen, Switzerland, and described on p. 747 of "Engineering News" of Oct. 8, calls to the mind of one of our readers, G. F. Schlesinger, of the department of civil engineering of the Ohio State University, the following simple method of getting approximate horizontal distances, for which he claims no originality, but which may be new to many readers:

The method, in brief, consist of turning off a horizontal angle of 1° 9′ with the transit, and then measuring the distance between the first and last pointings at the extremity of the course whose length is to be determined. This distance in hundredths of a foot, divided by 2, will be the actual distance in feet; depending, of course, on the fact that the sine (or tangent) of 1° 9′ is 0.02 (approximately).

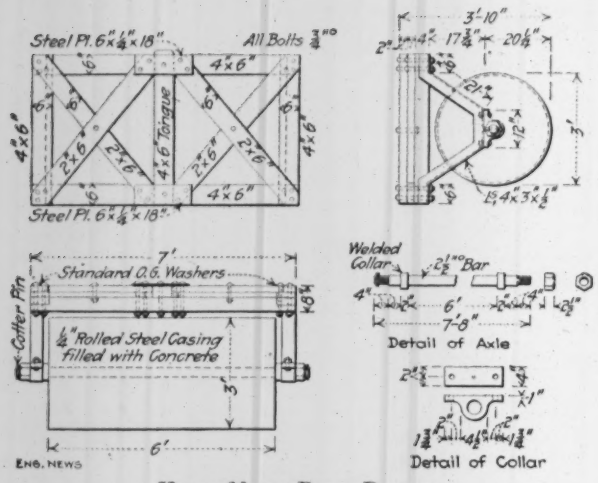
The angle of 34′ may be used, in which case the division by 2 is not necessary and the "spread" is one-half; but the approximation will be greater. The error due to the approximation using the angle 1° 9′ is 1 in 290, and, even in view of other inaccuracies, the results will be sufficiently close for certain classes of work.

By means of this method, remarkable progress can be made in determining small drainage areas by running an angle line around the divide; or, in some cases, by "side shots" from some central point or points within the area.

The party is composed of two men equipped with a plain transit, sight rod, metallic tape and ordinary chaining pin. The rodman selects the points ahead and the transitman takes the magnetic bearings of the courses (when practicable), then sets off the horizontal angle for lining in the rodman for the second pointing. The rodman, having inserted the pin, holding the ring at the end of the tape, at the first point, measures the distance to the second. After marking the first point so that it may be readily found by the transitman, he then proceeds to the selection of the next station, while the transitman moves up.

The following points can be made for this means of approximating horizontal distances: It permits the use of the plain transit reading to minutes with the ordinary cross wires, requires no stadia or level rod, no reduction to the horizontal, and longer courses can be taken than by the stadia or gradienter method. The transitman is not limited by the distance at which he can distinguish figures on a rod, but by the distance at which he can clearly see a sight rod.

Using Old Concrete Pavement Foundations—In New York we have laid both asphalt and stone pavements on the old concrete base. It is not all good, that is, we have to lay a certain amount of new concrete even on the old. The pavements are so cut up during the life of a useful pavement, for instance, 15 or 20 years, that the surface of the concrete foundation is very irregular after the asphalt is taken off. As a rule, it requires from 2 to 3 in. of new concrete to level it up.—George W. Tillson, in a discussion before the Cleveland Engineering Society.

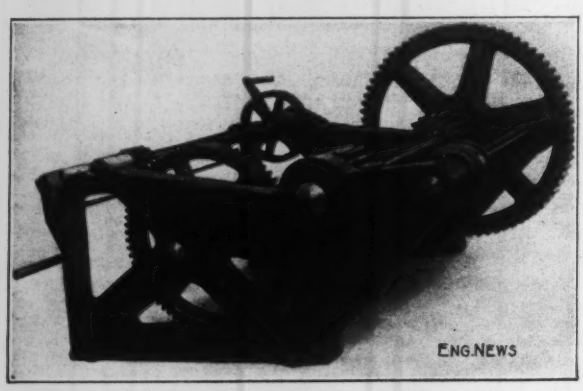


HOME-MADE ROAD ROLLER

A Home-Made Road Roller for $75—Many small towns which cannot afford to own a steam road roller may construct a very satisfactory substitute in the following manner, according to Bulletin No. 5 of the Pennsylvania State Highway Department:

The roller consists of a ¼-in. thick rolled steel casing, properly riveted with rivets countersunk on the outside and having a full head on the inside of the casing; but if an old boiler or a pipe of sufficient dimensions can be had, it will answer just as well. The axle is placed in the proper position and securely fastened, and then the casing is filled with concrete, well tamped. Great care must be taken not to disturb the axle from its proper position. The uprights on either end which support the wooden frame are made from steel angles of the dimension shown in the sketch and can be shaped and drilled by a blacksmith. The frame consists of 4x6- and 2x6-in. timbers cut and bolted together; the 4x6-in. pieces are notched at the ends and fitted into each other; the 2x6-in. pieces on top of each other, and square blocks of wood are inserted at the corners to give a solid bearing; a 4x6-in. opening is left on each side of the frame for the tongue, formed of the 2x6-in. pieces blocked up with a steel plate bolted over top; the tongue can be taken out and reversed instead of turning the roller.

Heavy Hand-Operated Gate Hoists, New York Barge Canal—The steel gates used on the New York Barge Canal line, in connection with the many dams and bulkheads required in furnishing water to private owners and for canal operation, are equipped with remarkably heavy manual hoisting winches. In estimating the force required to start these valves to open, and in designing the gate hoists, a very liberal factor has been used to allow for the extra resistance of gates frozen in and racks and pinions covered with ice and snow, as well as for the pressure of large amounts of floating debris, etc. The contractors were required in some cases to furnish gate hoists with which four men could exert a starting lift of 50,000 lb. It was required also that the hoists should close the gates under load.



A HEAVY HAND-OPERATED GATE HOIST, NEW YORK BARGE CANAL

(Maximum lift with four men at handles, 50,000 lb.)

In the hoists furnished by the Dilts Machine Works, Inc., of Fulton, N. Y., these requirements have been met by the construction illustrated herewith. The gate stems are 7-in. steel I-beams carrying 12x½-in. plates on the inner flanges and these in turn carry the rack sections. Each gate stem rises between a flanged roller and a 12-in. 18-tooth cast-steel pinion with 7-in. face. The shaft carrying the rollers is babbitted solid into the frames, the rollers turning on the shaft and not with it. There are three pairs of gears and pinions connecting back to the handles, the reductions being respectively $^{75}/_{15}$, $^{72}/_{12}$ and $^{72}/_{17}$. The 15-in. arm and 15-in. roller handle are detachable and may be slipped on the second gear shaft to give a higher lifting speed after the gate has been started. A cast steel ratchet and pawl on this shaft serve to hold the gate in any position. The heavy side frame castings are intended to be held in alignment principally by four 1¼-in. foundation bolts although there are three 1-in. separator rods.

To Prevent Wear of Concrete Floors, and the dust resulting from such wear under the influence of heavy trucking, etc., a chemical composition known as "Dustite" is being introduced. This is applied to the surface of a new or old floor, and is said to be proof against water, oil, acids and alkalies, while it enters into intimate combination with the concrete and will not flake or peel off. It is manufactured by the Dustite Co., 661 Peoples Gas Building, Chicago.

Rust-Resisting Metal Sheathing—Three of the new steel frame pier sheds built at Seattle, Wash., by the Port Commission are sheathed with galvanized corrugated iron of a special grade, having a high degree of purity and consequently a high resistance to corrosion. These properties are expected to make the sheathing durable and economical even under the influence of the damp and salt air of the water front at Seattle.

The metal used is known as Vismera iron, for which 99.80% of pure iron is guaranteed. Analyses by three commercial testing laboratories showed: Carbon, 0.011 to 0.46%; silicon, trace to 0.004%; sulphur, 0.017 to 0.029%; phosphorus, 0.004 to 0.006%; manganese, 0.03 to 0.050%; copper, trace to 0.025%; oxygen (given in one analysis only), 0.010%; total impurities, 0.116 to 0.120%; total purity, 99.880 to 99.884%. The makers state that a general average is 0.10% oxygen, 0.004% nitrogen and 0.001% hydrogen. A comparison of three physical tests showed the following: Elastic limit, 31,590 to 32,500 lb. per sq.in.; ultimate strength, 45,870 to 46,150 lb. per sq.in.; elongation, 32.7%; reduction of area, 63.5 to 71.4%.

This metal has been used also for roofing, culverts, window-frames and sashes, and a variety of other purposes where an important consideration is resistance to rust or corrosion due to moisture, acid fumes and other destructive influences. It is manufactured by the Inland Steel Co., of Chicago, which uses only pig iron and the crop-ends from the steel mill, no scrap being allowed in the mixture; this is believed to secure high strength in combination with a low percentage of carbon, phosphorus, sulphur and manganese.

Motor Trucks for Water-Works Service—For several years it has been apparent that the work of the Water Bureau could be made more efficient by substituting automobile truck delivery for the team delivery which has been used. For instance, each of the eight water pipe extension districts sends its team to the pipe yard for supplies and material almost every day. The district may require only two pigs of lead and three shovels; nevertheless, a team is required for a whole day to make the trip. It has been impossible to handle the entire delivery by team from the central yard. By substituting the motor truck it will be possible for a truck to start out with a full load in the morning and reach all of the districts on one side of the city. It is intended to use two trucks in the general delivery service of the water pipe extension division, one of five-ton and one of two-ton capacity. One two-ton truck will be used for delivery from water-works shops and one two-ton truck will be used for meter setting in outlying districts. These delivery trucks will not be assigned to specific divisions, but will be used for the work interchangeably as required. Three one-ton trucks will be assigned to the water-pipe extension division for use as emergency wagons to carry the repair gangs to leaks and breaks in the mains and to secure quick and efficient work in shutting off the water before damage is done. After careful study, specifications were prepared and bids were received for these seven motor trucks. A test run of 53.7 miles was held on Dec. 13, 1913. The trucks were carefully compared on the basis of design, construction, performance in test run and other features. Contracts were awarded on this basis.—From the recent annual report of John Ericson, City Engineer of Chicago, to the Commissioner of Public Works.

Editorials

The Abandonment of a Railway Line

A railway 90 miles long in Western New York was to be abandoned on Nov. 1, according to an order issued by the New York Supreme Court, which has directed the receiver of the property to cease all operation of trains and take up the track. The railway in question is that part of the Buffalo & Susquehanna Ry. extending from near Buffalo southeast to Wellsville. The company owning the road has been in the hands of a receiver for over four years. The court's action in ordering the discontinuance of operation of the road and the taking up of the track was made on petition of the United States Trust Co., of New York, the trustee for the bondholders of the company.

The facts appear to be that the road in question is the least profitable part of the Buffalo & Susquehanna line to operate. Lines located further south in Pennsylvania do an extensive coal business, but the difficult grades to the north make it cheaper to send the coal to lake ports over other roads than to haul it over the Buffalo & Susquehanna line from Wellsville. Undoubtedly, the bondholders have the right to stop operating an unprofitable property and to get what little salvage they can out of it by taking up the rails. This salvage will be small, however; for under present market conditions, relaying rails are salable only at a very low price.

The abandonment of the road will be a serious matter to the farming communities along it which depend upon it for transportation. The roadbed and tracks are in good condition, and represent an investment that could not be replaced, probably, short of $2,000,000.

Residents along the line of the road appealed to the New York Public Service Commission. Through the efforts of that body, the execution of the Court's order has been postponed for one month. It is hoped that prior to Dec. 1, the date at which the Court's order is now scheduled to take effect, someone can be found willing to take over and operate the road.

Of course, it is impossible to operate a road with thin traffic, such as this line has, at any such low rates per passenger-mile and per ton-mile, as prevail on roads which do a large business. It would be far better for the farmers along the line to pay whatever rate is necessary to keep the road in operation rather than have it stop operations entirely. More economical methods of operating the road could doubtless be introduced, such as substituting independent motor cars for regular steam-locomotive train service.

Such instances as this form a useful lesson as to the inevitable result where a railway is unable to earn enough to pay its operating expenses and make some return, at least, to those who have furnished the money to build it.

The railways are indeed public-service corporations and as such obliged to render reasonable service to all alike, so long as they continue in operation. But when any railway becomes unprofitable to its owners and they can see no hope for future profits, they have the undoubted right to do exactly what the owners of the Buffalo & Susquehanna R.R. propose to do—stop operations, take up the rails and sell them for scrap.

The only alternative to this would be the purchase and operation of the railway by the government, state or federal; but even if this were done, the necessity would remain of charging rates on passenger and freight traffic sufficiently high to pay at least the operating expenses and a safety margin over. It could hardly be expected to make up the deficit by laying a general tax on the public.

The Development of Sand and Gravel Deposits

The enormous development in the use of concrete in engineering construction which has taken place during the active life of men who still call themselves young, has been the chief influence in the rapid growth of two collateral industries, namely, the quarrying and stone-crushing business, and the utilization of sand and gravel deposits.

It is probably true that the value of gravel, properly cleaned and graded for use in making concrete material, has not been properly appreciated by the engineering profession until very recently. The old idea dies hard that the rough surface of broken stone made a stronger bond with the cement than the smooth surface of water-worn gravel, notwithstanding the numerous tests which have proved the perfect bond of the cement with the smooth gravel or stone.

It is now realized, nowever, that for reinforced-concrete work a good gravel concrete will run equally as well if not better around reinforcing bars than concrete made with broken stone; and where clean gravel is obtainable at a low price, there is every reason why it should be used by the engineer. In concrete-road construction, admittedly the most severe service to which concrete is now applied, a large proportion of the concrete roads thus far constructed have been built with gravel instead of broken stone as the aggregate.

The great increase in the market for sand and gravel has been accompanied by rapid developments in plant and machinery for handling these materials; and the design of such plants has now reached the stage where special knowledge concerning the operation of such a plant and the requirements to be fulfilled is necessary, if the best results are to be obtained in the operation.

While a number of descriptions of such plants can be found in engineering literature, there has nowhere appeared, so far as we are aware, any systematic discussion of the principles which should govern their design. We are, therefore, particularly pleased to be able to lay before our readers in this issue a paper dealing with this subject, prepared by an engineer who has had a number of years practical experience in the development and operation of sand and gravel deposits. The author of the article, W. H. Wilms, President of the Universal Sand &

Gravel Co., of Covington, Ind., has himself worked out the principles governing this class of work as a result of more or less costly experience in experimenting with different types of machinery and methods of operation. The article in this issue deals with the testing of sand and gravel deposits to determine their quality and the possibilities of their commercial development, and will be followed by succeeding articles dealing with the design and arrangement of the machinery and plant for operating such deposits.

Creosoted Wood-Block Paving Specifications to Prevent Bleeding and Bulging

The analysis of the new Kansas City specifications for wood-block paving, by Clark R. Mandigo, Assistant City Engineer of Kansas City, on another page of this issue, is of especial interest to municipal engineers. In presenting the Kansas City specifications to our readers, however, it is worth while at the same time to call attention to the new specifications of the Bureau of Highways of the Borough of Manhattan, New York City. These are the result of a very thorough investigation and study by a staff of expert paving engineers, and they differ in some essential points from the Kansas City practice.

The New York City specifications cover much more fully than those of Kansas City, the kind and quality of wood and the treatment of the blocks. Only genuine Southern long-leaf pine, subject to inspection in the stick before being sawn into blocks, is acceptable in New York. This must be air-dried, so that the blocks as cut shall not weigh more than 50 lb. per cu.ft.

When ready for treatment the blocks are divided into four lots, according to their varying weights per cu.ft. Those weighing 38 to 42 lb. per cu.ft., 42 to 44, 44 to 46, 46 to 50 lb. per cu.ft. are to be treated in separate batches under varying conditions of steam pressure, temperature and vacuum. The lighter wood is subjected to less pressure than the heavier and to lower temperatures; varying from 2 hr. at 15-lb. steam pressure at 185° F., and a vacuum of 22 in. for 1½ hr., at 155° F., to 5 hr., at 25-lb. steam pressure at 220° F., and a vacuum of 24 in. for 2½ hr. at 140° F. for wood weighing 50 lb. per cu.ft.

Besides detailed specifications for each batch as outlined, the specifications further state that variations and changes may be required by the engineer from time to time in the duration of the treatment and in temperatures and pressures used, to suit the specific gravity of oil and different varieties of timber used. All blocks and materials are inspected at the plant, but acceptance at the plant is merely tentative, the city reserving the right to reject shipments of block, as a whole or in part, after delivery on the work.

The New York specifications for the mortar bed (1:4) provide that the mixture shall be made dry and then slightly moistened before the true surface is struck. The mortar bed is also sprinkled immediately in advance of the block paving, from hand sprinklers—a different practice from that at Kansas City. No provision is made for wetting the blocks previous to laying, but it is specified that the blocks shall show such waterproof qualities that after being dried in an oven at a temperature of 100° F. for a period of 24 hr., weighed and then immersed in water for a period of 24 hr., and weighed again, the gain shall not be more than 5%. In laying, the blocks are specified to be laid loosely and not driven together—another difference from the Kansas City specifications. Either a coal-tar pitch or asphalt filler may be used.

On the other hand, experiments conducted by C. H. Teesdale, engineer in charge of wood preservation at the Forest Products Laboratory, Madison, Wis., tend to confirm the conclusions reached by those who drew the Kansas City specifications. These experiments were described in a paper read before the American Society of Municipal Improvements at the recent (October) meeting in Boston, Mass.

Mr. Teesdale's general conclusions are as follows:

> These tests seem to indicate that longleaf pine paving blocks should be treated in the green condition after being well steamed. All blocks, even if thoroughly air-seasoned, should be well steamed. While it is true that a preliminary and final vacuum greatly retarded bleeding of air-seasoned wood, a preliminary vacuum will tend to make the absorption of oil too rapid during treatment, resulting in uneven penetration. A steaming period is, therefore, advisable to render the absorption less rapid and allow a longer and more intense pressure period to be applied. Furthermore, if seasoned blocks are steamed, they will take up moisture and expand and should be less liable to give trouble from swelling after laying in the street. For these reasons it would be preferable to treat green material when it is possible to obtain it.
>
> If for any reason the blocks cannot be laid soon after treatment, they should be covered and perhaps wet down occasionally to prevent them from drying out. It is likely that if the blocks are wet when laid, expansion troubles will be much reduced, providing a good job of laying is done.
>
> It would seem to be desirable to give a vacuum treatment after the steaming period and also after the oil has been removed from the cylinder. If tar mixtures are used, a final steam bath should succeed the final vacuum to remove carbon and dirt from the blocks.
>
> Absorptions of over 16 lb. per cu.ft. hardly seem necessary. Data are available which show that heavier absorptions do not greatly retard swelling and they tend to increase bleeding.
>
> It seems very likely that the reasons why some pavements bleed while others do not may very often be traced to the method used in treatment. A plant treating green material would resort to a steaming and vacuum treatment with the result probably, that the blocks would give no trouble. The same plant, perhaps, would later treat seasoned material without steaming it or giving it a vacuum treatment. This would be the simplest method of treating such timber as much time would be saved, and these operations would seem unnecessary. When such blocks are placed in the pavement, however, there is considerable probability that bleeding would follow.

The following conclusions were drawn from all the tests made on swelling:

> (1) The rate of swelling was much slower in treated blocks than in untreated blocks. In all cases where the blocks were soaked in water the maximum swelling obtained was at least two-thirds, and in most cases was only slightly less than that of untreated wood.
>
> (2) The maximum swelling was less in blocks treated with tar mixtures than with creosote.
>
> (3) Free carbon did not appear to influence swelling.
>
> (4) No swelling occurred in the case of wood treated in green condition.

Engineers and Civil-Service Examinations

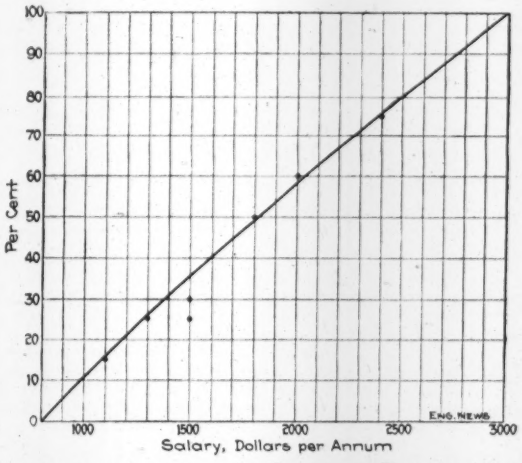
There can be no question that the engineering profession heartily supports the theory of what was known 25 years ago as the civil-service reform movement. It would be hard to find an engineer who would dissent from the proposition that appointments to positions in the public service, municipal, state or federal, should be based on the fitness of the applicant for the job and not on his political affiliations or his power to exert a pull.

But it is one thing to approve the theory of the merit system, and quite another thing to reach the conclusion that the average civil-service examination as it is con-

ducted actually does select the men or women who are best fitted for the work. It is a pretty general rule, we believe, that when an engineer is placed in responsible charge of work, and has to select the employees who are to carry out the work under his direction, he does not ordinarily appeal to the civil-service bureau for candidates unless the law obliges him so to do.

This applies especially to the higher positions, involving more or less of responsibility and originality in the men who are to fill the positions; but it applies also to the lower grades of city employment. Unless the bureau conducting the civil-service examinations goes at its job with the same common sense that should prevail in the employment bureau of a factory or a large mercantile establishment or a general contractor's organization, the examination of men for employment in the work of cleaning streets, excavating sewers, laying paving, firing boilers, and twenty other similar tasks in the municipal service is not likely to secure the men best fitted to perform the work.

An excellent statement of the engineer's attitude toward civil service in connection with a city's business is contained in the annual report, just issued, of Morris L. Cooke, Director of Public Works of Philadelphia. As



PERCENTAGE ALLOWED TO PREVIOUS EXPERIENCE IN CIVIL SERVICE EXAMINATIONS FOR ENGINEERING POSITIONS IN CLEVELAND, O.

many of our readers are aware, Mr. Cooke holds probably the highest administrative position in the service of a great city of any member of the engineering profession in the United States. He represents the reform element in politics, and has introduced into the public service of Philadelphia standards of efficiency such as have seldom been seen in that city. Mr. Cooke says:

> We wish to register a deepening conviction that some form of civil service is absolutely necessary for a proper conduct of municipal business. Were it not for civil service, the life of the average administrator would be almost unbearable.
>
> At the same time we are convinced that the civil-service system in this country is suffering from an overconfidence in its methods by those administering it. We believe that over a large part of the field the methods used are archaic; that as the grade of the position to be filled rises, the present methods of examining are less and less likely to produce the right kind of man. The civil service should be looked upon as corresponding to an employment bureau in the ordinary industrial establishment.
>
> Among the changes which would appear to be for the good of the system are: That the appointing officer should be allowed greater scope in signifying the particular type of employee he wants at any given time; more weight should be given to a candidate's previous experience and record and less to what he is able to submit in a four-hour examination; promotions should in greater measure be dependent on record of work done rather than on examination; civil service should be operated, primarily, to promote efficiency rather than to check favoritism.
>
> Methods should be adopted that will obtain quicker results from examinations. In departments such as those where there is a great deal of construction work that is not routine and which varies in amount from season to season, it is necessary at times to increase quickly the force in certain divisions. The most desirable candidates will not wait around two months after an examination to find out whether they are to be available for appointment.

We wish that Mr. Cooke's comments above quoted might be read and taken to heart by all those charged with the responsibility of conducting civil-service examinations. The fact ought to be recognized that there are a large class of men who are competent and efficient in doing work but who can by no means attain a high mark in an examination.

Worth especial notice in this connection is the method adopted in the City of Cleveland a few months ago to comply with the civil-service law and at the same time meet the practical needs of municipal service.

The new Cleveland charter, which went into effect at the beginning of the present year, made it unlawful for a city disbursing officer to pay an employee in the classified service unless the city Civil Service Commission had certified to that person's appointment in accordance with the civil-service provisions in the charter. The charter, however, provided that:

> All examinations shall be practical and impartial, and shall relate to those matters which will fairly test the relative capacity of the person examined to discharge the duties of the position for which appointment is sought.

The Cleveland Civil Service Commission is composed of two lawyers and a chemist. After a rather unsatisfactory experience in having its papers for the examination of engineering employees prepared by examiners selected by the Commission, an appeal was made to the Cleveland Engineering Society for aid.

The society at once appointed a special committee which prepared lists of those members of the Society who were by previous training and experience best qualified to prepare examination questions for the various positions. From these lists a subcommittee of two was selected for each examination.

Consultations were held by the committee and the various subcommittees with the commission as to the routine and scope of the work and the relative weights to be given to examination and previous experience. It was felt that in the subordinate positions it is of importance that a man should have thorough technical knowledge but that as responsibility is increased, experience becomes the most important thing. This was apparently recognized by the framers of the charter when they conferred upon the Commission power to exempt certain positions from the competitive class.

It was necessary to reduce this general idea to a definite basis and the committee finally decided that a position paying not more than $800 a year might be filled by a man with no previous experience, while one paying $3000 or more should require a man of such extended experience that his early technical knowledge might be relatively of no importance. Between these two extremes the weight of experience was made relative to salary on a nearly straight line, as shown on the accompanying cut.

Letters to the Editor

Experience with Small Cube Granite Block Pavements in Louisville, Ky.

Sir—Supplementing the article in ENGINEERING NEWS, Sept. 10, 1914, on "The Present Status of Small Cube Granite-Block Pavements," the following facts regarding Louisville experience may prove of interest. The Department of Engineering has recently laid about 600 sq.yd. of this pavement in the car tracks on Main St. between 7th and 8th St. The blocks were purchased from the Harris Granite Quarries Co., Salisbury, N. C., and cost $9.30 per ton f.o.b. Louisville (7 sq.yd. to the ton guaranteed). The blocks measure from 3¼ to 4 in. and are in the form of irregular cubes.

The foundation for this pavement is portland-cement concrete extending from a line 6 in. below the ties to a line 4¼ in. below the head of the rail. On the concrete foundation was spread a course of pea gravel or roofing gravel in which the blocks were set in straight courses perpendicular to the rail. No especial effort was made to break the joints as this was accomplished by the irregular sizes of the cubes. After laying, the blocks were rolled with a 2½-ton tandem roller and grouted with a portland-cement filler.

To date, the pavement is entirely satisfactory and presents a beautiful appearance, but the short time it has been in use, about three months, is not sufficient to furnish any reliable information.

The cost of the blocks on the railroad cars was 67c. per sq.yd. less than standard-size blocks would have cost from the same quarry, and the amount of filler used was about the same required for standard blocks. However, the cost of paving was considerably higher, as we could only secure a maximum of 20 sq.yd. per man per day of 9 hours, whereas on standard blocks we have no trouble in getting 30 to 35 sq.yd. per man. Granite pavers of this city are paid 50c. per hr., or $4.50 per day; consequently it will be seen that it cost about 50% more to pave with the cubes than with the standard blocks. It should be remembered in this comparison, however, that these blocks were used in the car tracks which always cost more than paving larger areas.

This experimental section of "Durax" pavement has given such favorable impression that we have just awarded contracts for laying 4000 sq.yd. of it on another street. The lowest bid on this contract was $3.10 per sq. yd. including a 6-in. concrete base and portland-cement filler.

While we think this price is a trifle high, we account for this because of the fact that the pavement is practically an unknown quantity to local contractors and we think they have added a liberal margin for safety. We have decided, however, to let the contract at this figure hoping by keeping cost account on it to show that it can be laid considerably cheaper than $3.10, and in this way we expect to bring the price down to a more reasonable figure.

From our investigation of this pavement and our slight experience with it we are so favorably impressed that we hope to be able to lay larger yardage of it in the future if it can be done at a reasonable figure.

D. R. LYMAN,
Chief Engineer, Department of Engineering.
Louisville, Ky., Sept. 19, 1914.

Slighting the Humble Land Surveyor

Sir—I have often wondered why that part of engineering dealing with land surveying has apparently not received in the periodicals of the day the amount of attention and discussion it deserves. Is this because there seems to be a quite general belief, even among engineers, that anyone who can run a transit and read a tape is a surveyor?

A case in point might readily be found in the report of the Committee of the Philadelphia Association of Members of the American Society of Civil Engineers, printed in ENGINEERING NEWS, Oct. 22, 1914, pp. 850-852. After setting forth in an able manner indeed, a number of arguments against the proposed act and its principles covering the licensing of professional engineers, the committee recommends a plan, to quote, in part:

> To require the licensing of county surveyors and other surveyors in independent practice. Fair examinations for surveyors can easily be set, which would serve to exclude incompetent men where incompetency would be likely to entail property losses and expensive litigation.
>
> To license other classes of technical men whose duties are of a definite and restricted nature in fields where incompetency would be attended by results similar to those just mentioned in connection with surveyors, and in which competency may readily be determined by examinations.

Here is clearly a case where land surveying is regarded as a fixed and definite proposition, as much so as a problem in trigonometry. The committee report would lead one to believe that its members feel that given a set of circumstances and data, there is in all cases but one correct procedure for a good, let us say a "properly licensed" surveyor to take.

Unfortunately, this is not true. The first part of paragraph (b) under heading (A) in the above report is a good answer to the proposed plan to license surveyors anywhere; for in what part of engineering work is there more judgment required than that of the land surveyor? Besides having often to interpret deeds, descriptions, laws, titles and right of possession, he is obliged to use extraordinary care, and all of his experience, in order to insure *accuracy* at all times in "mere measurement." In practice, this is not a matter of running a transit and reading a tape, as a glance at some of the U. S. Coast and Geodetic Survey reports, covering accurate measurements of various kinds will prove.

To quote again from the above report:

> It may, in fact, be confidently affirmed that no plan of licensing can serve to eliminate unscrupulous, though technically competent, men, who will not hesitate to resort to

unprofessional practices insofar as that may be possible with safety to themselves.

Where in the whole field of engineering is there another department, like land surveying, where competition is as keen, with its resultant price-cutting and lowered quality of work, and by reason of the almost criminal lack of proper laws, the chance for careless and troublesome practices so great?

It is true that the land surveyor has not the responsibility of the danger of a catastrophe resting upon him; but from a theoretical point of view there is more judgment, or say more educated common sense, required at times in land surveying than in the design of a bridge or other structure of more or less standard specifications.

The writer is not opposed to the licensing of surveyors as a general proposition since this would perhaps require a working knowledge of mathematics at least, among the "surveyors." The true remedy, however, in my belief, is in the enacting of proper laws covering land descriptions, plats, monuments, etc.

MATHIAS R. KONDOLF.
P. O. Box 713, Rochester, N. Y., Oct. 24, 1914.

A Defense of Railway Location Theories for Highway Location

Sir—In your issue of Aug. 6, 1914, there was a letter under the title of "Highway Location in Mountainous Country." I wish to mention the experience of the writer on highway work with engineers "who had sat at the feet of Wellington," or other high authorities on railway location, and who, the author of that letter seems to think, are not particularly qualified for highway-location work.

In the Philippine Islands we have had engineers with highway, railway and other special experience, and engineers just out of school with no practical training at all.

Where one location made by the railway engineer has been found wanting, a dozen made by men with other than railway experience have not come up to the requirements. Engineers with former highway experience were not found to have any marked advantage over those without railroad experience.

It is an extremely rare occurrence that we have to request the ex-railway engineer to break his grades at more frequent intervals, or that we have to increase his rate of grade or cut down the radius of his curves. On the other hand, it is the rule rather than the exception that the locations made by the non-railroad men are noticeable for the following defects; adverse grades (often maximum both ways), when a broken or uniform grade can be had for the same or but little greater expense, and in some cases for even a lower cost than for the adverse grade (usually there is no attempt to locate these grades with any regard to momentum factors); poor alignment; excessively sharp curves without any reason for their adoption.

We have a form of parabolic curve in the engineers' manual, which can be advantageously used in some cases. This curve may be easily located by offsets.

A common method used by some non-railway engineers is to run in their curves with a certain length of tangent distance, which length remains practically constant for a section of location, with little or no attention to the amount of angle, topography or other conditions. These engineers assume that a tangent distance of say 100 ft will get them around almost any angle and they are content. Frequently curves of from 1° to 20° or more will be made where a tangent would not cost a cent more.

These cases often occur in a country where a swing sufficient to give a straight line would not make any difference in the grading required. This generally comes from running to a point where the locating engineer discovers he has to make a turn to strike his objective point. Light angles come in frequently from getting off a back sight or other cause; but such little things as a rule do not bother the man who has not "sat at the feet of Wellington." However, such defects do not pass entirely without notice from the more or less critical nontechnical users of the road.

The railroad engineer has an eye for country and has methods of overcoming difficulties in grade and alignment, which are not possessed by one engineer in a hundred who has not had his experience or worked on location under the direction of a highly qualified location man.

The writer of the letter in your Aug. 6 issue states: "Highway location is still in its infancy, and a few more railroad ideas will have to be almost forgotten." After going over considerable highway work in the United States, Europe and the Malay States and having had about eight years' experience on road location and construction in the Philippine Islands and Cuba, I believe that the last phrase would be decidedly of more value to the highway cause if it had read "a few more railroad ideas will have to be kept in mind."

I fear that the writer of your letter must have been rather unfortunate in his experience with railroad men on highway work, and one cannot help wondering what kind of railroad men he had to deal with. I do not know of any branch of engineering where men can make money go further or make a dollar earn any more interest than the first-class railroad locating engineer, either on railway or highway location.

Is there any set of engineers who are oftener required to break their long grade lines, use heavier rates of grade, adopt sharper curves and otherwise lower their ideal standard of excellence in order to get their line through for the funds available than the railroad locating engineer? If he can do this on a railroad, he can also do it on a highway.

I do not wish to be understood as harshly criticizing men who have not had the benefit of railroad experience. Many of these men have done and are doing the highest class of highway work. When the man with the non-railway experience understands what is wanted *and how*, he is as efficient as the railway man.

It is undoubtedly true that all railroad men are not successful highway locating engineers; but I believe that, as a rule, the railroad locating engineer will make better road locations than men from any other school of practice. I also believe that the number of unjustified sharp curves and the heavy grades found in easy country, which have been laid out by nonrailroad engineers, will greatly outnumber the unwarranted light grades and too easy curves in mountainous country for which men of the Wellington school can be held responsible.

W. H. WAUGH,
Senior Supervising Engineer,
Bureau of Public Works.
Manila, P. I., Sept. 18, 1914.

The New York Rapid Transit Railway Extensions*

By F. Lavis†

V--Ventilation, Drainage and Waterproofing

Ventilation

Every effort has been made to so design the new subways, that the excessive heating which occurs at times in the summer in the present subway may be avoided. The tracks are to be divided so that trains going in one direction will be in a separate tube or tunnel from those going the opposite way; by this means it is expected to utilize the movements of the trains (the so called piston action where there is only one track in a single tube) to push the air ahead and out through the openings which are provided for this purpose.

The original subway is completely surrounded by an envelope of waterproofing, and it has been thought that this has prevented the dissipation of some of the heat generated by the motors, brakes, friction, etc., into the ground surrounding the structure. On the new lines waterproofing will generally only be used where actually necessary to keep out water, that is, below the ground-water line, in earth, and on the roof.

Openings in the roof of the tunnel, with sidewalk gratings, are provided over the station platforms, and generally one about half way between each station and one at each end of the stations on the side toward the approaching train, these latter being expected to take care of most of the draft caused by the train, instead of allowing it to create a current at the platform and up the stairways. The general form of these openings, and the details of their construction are shown in Fig. 22, and a typical arrangement of location in Fig. 21 (7th Ave., 17th to 24th St.). The dimensions and numbers of these openings have been so fixed that it is expected that the current of air coming through the gratings in the sidewalk will be barely noticeable to pedestrians.

Fan chambers, which are all arranged so that they may be also used as emergency exits to the streets, are provided, one about midway between each station. They are so arranged that they will draw the air from the tunnel at points intermediate between the stations and blow it out through the gratings already described, thus, of course drawing fresh air in at the stations. It is expected that the openings alone combined with the action of the trains will ordinarily provide sufficient ventilation, the fans being used only occasionally when circumstances require.

The piston action of the trains in the single-track tube of the Hudson & Manhattan R.R. has been noticeably efficacious in promoting efficient ventilation, but except on the Fourth Ave., Brooklyn line, where there is a parked space in the center of the street and where walls are provided between each track, it was not considered practicable to divide all the tracks of the new four-track lines so that each would be in a separate tube, on account of the difficulty of providing outlets for the center tracks. It would be impractical, of course, to provide openings in the roadway of the streets, and in order that the openings in the sidewalks might be used, the center wall only was built dividing the traffic going in opposite directions, but leaving the two tracks on one side in the one space. If this does not produce the required movement of the air, that is, actual propelling movement, not mere stirring up as in the present subway, the fans must be utilized to supplement it. Openings about 2 ft. wide and 8 ft. high are provided at every 10 ft. in the center wall as a means of communication between the two sides, and as refuge niches, and these may tend to reduce the piston effect to some small exent.

Although this arrangement in the four-track section will reduce somewhat the positive piston action of the trains, it will be beneficial to the extent that it will tend to reduce the air resistance, which has been shown* to be by no means a negligible factor in cost of operation in single-track tubes, though this cost may be offset by the benefits of more efficient ventilation.

The actual effect of all these different items and of the size of the cross-section both on the efficiency of ventilation, as well as the cost of operation, is something of which little is actually known, but in view of the enormous expenditures which are being made and which undoubtedly will continue to be made in underground railways for rapid transit, in subaqueous tunnels, etc., it is hoped that further experiments along the lines of these already referred to* and others of like nature may be continued.

As will be seen by the diagrams, the object of the design of the openings has been to provide at the track level a space into which the air pushed ahead of the train may expand and be detained, instead of being pushed by, and then provide an opening above through which it may escape to the surface, there being apparently little reason to doubt the efficacy of this proposed scheme.

Drainage and Waterproofing

In the general clauses of the specifications it is stated that "it is the very essence of these specifications to secure a railroad structure underground which shall be free from the percolation of ground or outside water. The mixing and placing of the concrete and the placing and protection of the waterproofing shall be with this end in view.

"In general, waterproofing of the structure will be limited to the roof and sidewalls at the stations and over the roof between stations, and to those surfaces near ground water or mean high water if ground-water level is found for any reason to be below mean high water. At other places free drainage shall be provided by pipe drain, hollow tile or broken stone."

The specifications provide for the use of fabric waterproofing, laid in hot pitch or asphalt, and in from three to six thicknesses or plies, and for brick or hollow tile, laid in pitch or asphalt mastic. The latter to contain "one-

*Copyright, 1914, by F. Lavis.
†Consulting Engineer, 50 Church St., New York City.

*J. V. Davies, "Air Resistance in Tube Tunnels," "Trans.," Am. Soc. C. E., Vol. LXXV, 1912.

third pure bitumen, and sand and cement or lime dust in proportions governed by local requirements and weather conditions."

At temperatures of 50° to 70°, the proportions used are usually one-third asphalt, one-third cement, one-third sand; in colder weather the proportion of asphalt is increased as required up to a maximum of 60%, though 50% is seldom exceeded. Lime dust is apparently not used in place of the cement, as it appears to require a larger proportion of asphalt to make it workable.

The fabric waterproofing is generally used on the roof or other horizontal surfaces where it may be required, and the brick in mastic on the sidewalls or on any vertical

protected from injury by barricades or otherwise, if necessary until thoroughly set.

It is intended to obtain concrete impervious to water; the concrete shall be mixed and deposited with this end in view, and on the roof of the railroad, if waterproofing is not used, the top surface of the concrete shall be carefully troweled as may be directed in order to add to its imperviousness.

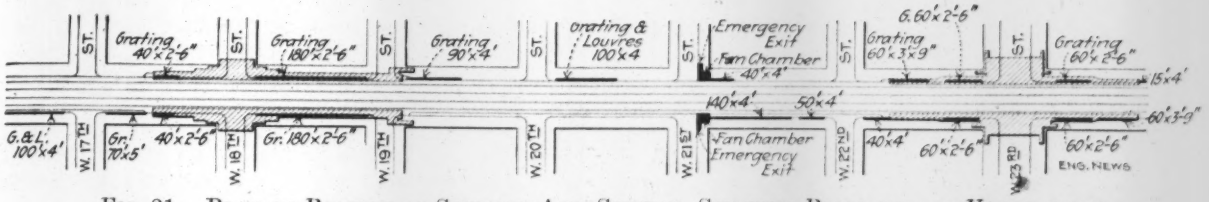


FIG. 21. PLAN OF PORTION OF SEVENTH AVE. SUBWAY, SHOWING PROVISION FOR VENTILATION

Reference has already been made to the fact that on account of the supposed influence of the waterproofing envelope inclosing the present subway, in retaining the heat, that waterproofing is only carried out in the new lines where the evident necessity shows the need of protection to keep the structure reasonably dry. Much greater reliance is being placed on the provision of free

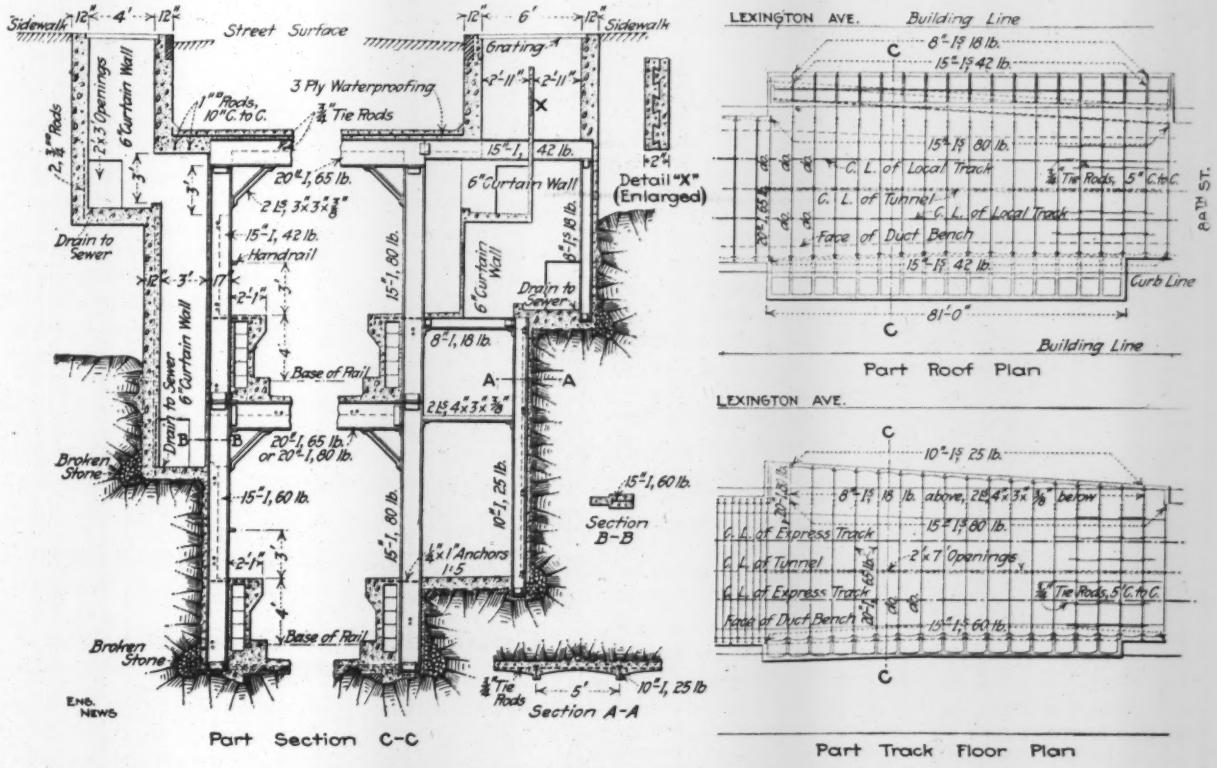


FIG. 22. PARTIAL CROSS-SECTIONS AND PLANS OF DOUBLE-DECK SUBWAY, SHOWING TYPICAL ARRANGEMENT OF VENTILATING OUTLETS

surfaces and under the floor when required there. At stations brick and mastic are used over the roof.

In the concrete specifications, the following clauses apply to the waterproofing:

The proportions of cement and sand and stone (or gravel) used in making protective concrete outside of waterproofing lines on sides and roof, shall be as follows: 1 part of cement, 4 parts of sand and 8 parts of stone.

Concrete to which waterproofing is to be applied shall be made smooth at the time of laying and shall be carefully

drainage to take care of small quantities of water, than has been done heretofore, this being in line with recent experience.

The question of waterproofing tunnels is comparatively modern and its importance is due principally to the development of electric traction and of the numerous underground lines for urban rapid transit. On that section of the Pennsylvania Railroad's New York tunnels,

which passes under the Bergen Hill* on the Jersey side of the Hudson River, and where there was a considerable seepage of ground water, the ample and careful provision of free drainage, without the general use of waterproofing has resulted in a remarkably dry structure.

On all the new subway lines, drain pipes are laid in the floor (under the center of each track) which lead to sumps at pump chambers, from which the drainage is discharged by automatic electric pumps into convenient sewers.

These floor drains have grating openings in the concrete floor every 50 ft. and the floor grades are arranged (irrespective of the track grades) so that there is a summit between each grating (in the case of steep grades 2 or 3%, the summit is just below the grating), 4-in. pipes lead to these center drains from the sides, and, if necessary, part or all the way up, to take care of any seepage there may be. In the case of the Lexington Avenue rock tunnels, these side drain pipes generally reach up to the bottom of the loose rock packing over the roof. See Figs. 12 and 14.

Speaking generally, there are two typical methods of waterproofing. The first where the structure is in earth, where the water level (mean high water or ground water) is above the bottom of the structure. In these cases the waterproofing is carried across the bottom and up the sides to about 2 ft. above the level of the water. See Fig. 15. This drawing also shows the waterproofing carried over the roof, as the section is taken at a station.

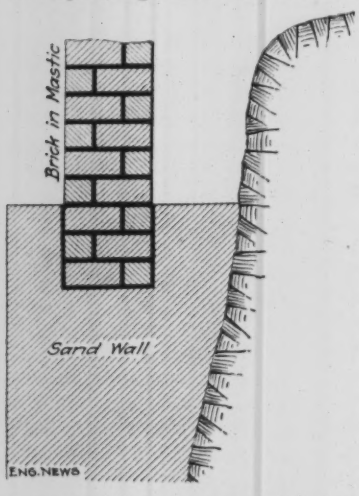


FIG. 23. EXAMPLE OF WATERPROOFING STRUCTURE IN ROCK WITH BRICK WALL LAID IN MASTIC

The second where the structure is partly in rock and where the water level is above the rock. In these cases the waterproofing is carried from a point 2 ft. above the water level to the rock or more commonly sealed into a trench in the sand wall, as shown by the sketch, Fig. 23.

When the water level is below the top of the rock, waterproofing is not generally used except over the roof (see Fig. 12), and in the case of the Lexington Ave. tunnels, even this is omitted.

The necessity or otherwise of using the waterproofing is, of course, governed entirely by the local subsurface conditions, the plans provide for what may reasonably be expected, based on the results of the borings, but the judgment of the field engineers is relied on largely to modify this to conform to actual conditions developed as the work progresses.

In that section of Lexington Ave. south of 100th St., where the structure is in rock tunnel and wholly above the water level, no waterproofing at all is used; on the other hand, just above this point, at about 102nd St., though the structure is wholly in rock, the water level is about 10 ft. above the bottom of the structure and the brick in mastic is, therefore, carried down below the floor at the sides, and the top is covered with 1 ply of fabric and two layers of brick in mastic. Burlap coated with an asphalt compound is generally used for the fabric, but where there is water, as in the bottom under the floor or in depressed bays, etc., one layer of felt is used first.

At stations the waterproofing (3-ply fabric or 1-ply and two layers of brick in mastic) is carried over the roof and down the sides to below the track level, in order to prevent any damage to the decorations, as well as to protect the offices and passengers.

When the floor is to be waterproofed, a 6-in. concrete base is laid in the bottom of the excavation, and two layers of brick laid flat in mastic laid on this; at the sides, if the sheeting is to be left, the two courses of brick in mastic are generally laid right against it, otherwise, where the sides require waterproofing, the steel is first erected, then a hollow-tile or concrete-sand wall is built behind it, on which the waterproofing fabric is hung and then the concrete sidewalls are built. Loose rock is packed behind the hollow tile as it is built up.

In many cases the protection wall of 4-in. hollow tile, or a concrete sand wall is built, then the steel is erected before the brick in mastic is laid up. The steel columns then act as braces for the rough board forms necessary to support this latter until the mastic hardens. These boards are usually painted with a good thick coat of cement grout to prevent their sticking to the mastic, the grout sticks to the mastic and the boards are easily removed.

An inspection of the various bids made up to the present time shows the general average prices for the above classes of work on the contracts awarded to be approximately as follows:

Waterproofing, 1 ply per sq.yd	$0.50 to $0.60
Waterproofing, 2 ply per sq.yd	0.80 to 0.90
Waterproofing, 3 ply per sq.yd	1.10 to 1.20
Waterproofing, 4 ply per sq.yd	1.35 to 1.50
Waterproofing, 5 ply per sq.yd	1.55 to 1.75
Waterproofing, 6 ply per sq.yd	1.75 to 2.00
Brick in mastic, per cu.yd	27.00 to 30.00
Vitrified drain pipes, 4 in. per lin.ft	$0.40
Vitrified drain pipes, 6 in. per lin.ft	0.50
Vitrified drain pipes, 8 in. per lin.ft	0.75
Vitrified drain pipes, 10 in. per lin.ft	0.90
Vitrified drain pipes, 12 in. per lin.ft	1.10
Cast-iron drain pipes, 4 in. per lin.ft	$0.75 to $1.00
Cast-iron drain pipes, 6 in. per lin.ft	1.00 to 1.25

Concrete Roads in Wayne County, Mich.

The eighth annual report of the Road Commissioners of Wayne County, Mich., just issued, is of interest to all who are following the progress of concrete-road construction. That these are numerous is indicated by the statement that hardly a day has passed throughout the year without the visit to Wayne County of a delegation from some part of the United States and Canada to examine the concrete roads.

The county now has over 100 miles of concrete road, some of it in its sixth year of service. The Commissioners say that as these roads are without the semblance of a rut and not a single 25-ft. section has been taken up and replaced since its beginning, the adoption of the concrete road as the standard type for Wayne County is justified.

*The Bergen Hill Tunnels of the P. R.R. Trans. Am. Soc. C. E., Vol. LXVIII, p. 146.

The success of the Wayne County roads is further evidenced by the adoption of concrete for roads elsewhere in the vicinity. The City of Detroit will put under contract during the present year over 139,000 sq.yd. of concrete paving for streets and alleys. A number of cities and villages near Detroit and across the river in Canada are laying large amounts of concrete road and street paving.

The Commission announces that it has abandoned the construction of roads having a width of concrete of less than 15 ft. and 24 ft. with the shoulders. A number of its existing concrete roads are only 12 ft. wide; but it has been found that when these narrow roads are opened, the amount of traffic attracted to them makes it desirable to have a greater width. In other respects the specifications used last year are unchanged. The principal endeavor now in the road work is to secure a surface even and level, free from wavy depressions and irregularities.

A notable feature of the Wayne County road work is that it is practically all done by day's work by the Commission's own forces, there being at times some 600 to 800 men employed.

The board alludes to the difficulty experienced in financing the work by the sale of county bonds which bear only 4% interest. It became necessary in order to sell the bonds, to appeal to the public spirit of local financiers. Of the entire issue sold last year of $368,000, the Ford Motor Co. took $100,000.

A large part of the cost of concrete-road construction is hauling the material onto the work. The Wayne County plant includes an industrial railway outfit, 100 to 150 teams and wagons and eight traction outfits. The industrial railway is of 2-ft. gage with portable track in 15-ft. lengths. The rolling stock consists of a 7-ton 30-hp. locomotive, 60 steel dump cars 1½ yd. capacity, and five 16-ft. flat cars. The locomotive will haul 30 loaded cars.

Where the industrial railway is not available, material is hauled by teams and tractors. The teams work economically on short hauls, but are often difficult to secure in the road-building season at reasonable prices. Road rollers are largely used for traction, hauling wagons carrying a seven-ton load. Over earth roads this is about all one tractor can haul. Where, however, a concrete road is available for hauling, six wagons carrying 42 tons of material are made up into a train and hauled by one ten-ton roller.

A large amount of water is required in making the concrete road, not only for the concrete but to puddle the subgrade in advance of the concrete laying. It has been found economical to lay a 2-in. pipe along the road from the nearest source of supply and pump the water by gasoline engine or electric motor. In some cases water has been delivered in that way over ten miles from the pumping station.

Curing of the concrete after laying is an important matter. Following the laying of the concrete, it is covered with 2 in. of sand or loose soil, and this is sprinkled daily for ten days. The road is not opened to traffic, however, until three to six weeks have elapsed, according to the season of the year. The shoulders of the road are built of crushed stone or gravel from 3 in. to 7 in. thick and 3 to 4 ft. wide on each side of the concrete.

An interesting section of the report is that on maintenance, as critics of concrete roads have maintained that the cost of keeping them in repair will be excessive. The report, however, contains no separate figures as to the cost of maintaining concrete roads. The total amount expended for repairs on all county roads during the year was $23,393, a saving of $7140 over 1912. This total, however, includes the maintenance of all the gravel and macadam roads in the county as well as the concrete roads; oiling and heavy repairs on the gravel roads and dragging after rain, cleaning of ditches and culverts, and painting of bridges and guard rails, and such necessary work as cutting brush, weeds, etc., and cleaning ditches. The method of repairing cracks or spalling at the joints of concrete roads is the same that has been used in previous years, viz., filling the crack with hot Tarvia of a grade melting at about 80° F., and covering the top with dry sand.

Annual Meeting of the Northwestern Road Congress

The Northwestern Road Congress, organized some months ago, held its first annual meeting at the municipal Auditorium at Milwaukee, Wis., on Oct. 28-31. The attendance consisted largely of township and county officials.

Prof. T. R. Agg (Iowa State University), was President of the Congress. Mr. Hazlewood, Vice-President of the Congress (and Chairman of the Wisconsin Highway Commission), spoke strongly of the necessity of keeping the work and appointments free from political influence.

A paper by Prof. Brindley (Iowa State University) on "The Functions of the State and the County in Highway Administration" had as its keynote the absolute necessity of fixed responsibility and competent supervision to insure good work and economical use of the public funds. He advocated putting the care of secondary roads (representing 75% of the total) in the hands of a responsible commissioner for each township, and the main roads under a county enginer, with a State Commission and enginer in general supervisory charge over all roads, bridges and culverts.

A paper on "The Authority and Responsibility of the County Engineer or Commissioner" was read by Grover Blunt, County Engineer of Fayette Co. (Iowa), and one on "The Inspection of State-Aid Road Work," by John T. McDonaghey, Chief Inspector of the Wisconsin Highway Commission. The latter outlined the system employed in Wisconsin, which was reviewed in ENGINEERING NEWS, Oct. 15. A paper on "Day Labor or Contract Systems for Road Building," by A. R. Hirst, State Highway Engineer of Wisconsin, was very strongly in favor of the former system, as being the more economical and efficient, except for large jobs or for work requiring more special equipment than it would pay the local authorities to own. He stated that in Wisconsin, contract work is rarely done within the contract price, while the engineers of the highway commission are getting work done better and at less cost than it could be done by contract.

In regard to legislation, a paper on "Practical State-Aid Policies," by Mr. Gash (President of the Illinois Highway Commission), reviewed the recent revision of the road laws in Illinois. In the discussion, Mr. Mullen, of the Minnesota Highway Commission, discussed the ques-

tion whether the state should undertake construction or simply render financial and technical assistance to counties and townships. In Minnesota the latter system is employed, with the important feature that it provides for continuous maintenance of all roads.

A paper by John N. Carlisle (State Commissioner of Highways of New York) was unfavorable to the special-assessment method for financing county road work.

A set of six papers dealt with the technical side of road construction as follows: "Brick Roads," by Mr. McCleary, Engineer of Cuyahoga Co., Ohio; "Concrete Roads," by Mr. Kuelling, Highway Engineer of Milwaukee County; "Bituminous Concrete Paving," by Mr. Simmons, Commissioner of Public Works, of Milwaukee; "Gravel and Macadam Roads," by Prof. Agg. Iowa State University; "Earth Roads," by Mr. Sargent, District Engineer of the Wisconsin Highway Commission; and "Highway Bridges and Culverts," by Prof. Marston, Iowa Highway Commission.

Leakage in the Moodna Tunnel of the Catskill Aqueduct near the Hudson River Crossing

Bids are now being called for in our advertising columns, to be opened on Nov. 10, for driving a shaft some 400 ft. deep and a section of tunnel about 900 ft. long to supplement the existing Catskill Aqueduct on the west shore of the Hudson River at Storm King, where the aqueduct approaches the river.

The circumstances which have led to the undertaking of this work are of considerable engineering interest. It will be recalled that the Catskill Aqueduct, from the Ashokan Reservoir in the Catskills to the high level distributing reservoir just north of New York City, is composed of cut-and-cover concrete conduit, tunnels at hydraulic gradient through hills and pressure tunnels deep in solid rock beneath certain major valleys. Under New York City itself also the distribution is to be by a deep pressure tunnel in the rock.

It is well understood, of course, that pressure-tunnel construction can be successfully used only where the rock is solid and unyielding. Concrete lining is put in merely to close possible interstices in the rock, to aid in making the rock more water-tight by grouting and to furnish a smooth surface for the water to flow over. The enormous bursting pressure exerted by the water in this huge aqueduct, 14 ft. in diameter, under a head of several hundred feet, would, of course, rupture any concrete lining which could be placed were it not for the resistance of the solid rock back of the lining.

The Catskill Aqueduct passes under the Hudson River at Storm King through a rock tunnel driven at a depth of 1100 ft. below the water surface. The opposite ends of this tunnel connect with shafts reaching to the surface. In the shaft on the west side of the river, at a depth of 228 ft. below the water level, or about 270 ft. from the surface of the ground, connection is made with a tunnel leading to the westward, the so called Moodna pressure tunnel, driven through the solid rock under the northern toe of Storm King Mountain.

The West shaft of the Hudson siphon (like the East shaft) was sunk by the city as a test shaft to gain information leading to the construction of the siphon. Having developed unusually sound and water-tight rock, was believed worth while to use this shaft as a part the siphon, thus saving the expense of another sha farther west and the consequent additional step in th profile of the tunnel.

The rock was carefully inspected as the shaft w sunk and to all appearances it was, in the judgment o the engineers, stable and unyielding, and unusually fa orable material for a water-tight conduit.

The lining of this section of the tunnel was complete last winter, and it was later subjected to the full designe water pressure, with the result that a considerable volum of leakage developed beneath the West shaft and the nex shaft, 520 ft. west of it. When the tunnel was pumped out and inspected, it was found that notwithstanding the fact that the minimum depth of rock cover was, as stated above, 270 ft., there had been a slight yielding of the rock at certain points with the result that the concrete lining had been cracked, permitting water to escape. These cracks were very small, the widest, we are informed, being only one-eighth of an inch in width; but under the enormous head, even these small cracks permitted the escape of a large quantity of water, although only a very small percentage of the aqueduct's capacity. No evidence whatever of the movement of the rock is detectable at the surface of the ground.

When the tunnel is once put in operation and becomes a reliance of the city for its water-supply, it must be dependable. Moreover, since the statistics of growing water consumption in New York show that the entire Catskill supply may be needed by the city at no distant date, every means possible must be adopted to reduce the amount of leakage from the tunnel.

Under these conditions it was deemed to be desirable to abandon the use of that part of the West shaft of the Hudson River siphon nearest the surface and of a small part of the Moodna pressure tunnel connecting with it. The work on which bids are now called for involves going back 900 ft. farther into the solid rock of Storm King Mountain along the Moodna pressure tunnel, making at that point a shaft 400 ft. in depth, and from its bottom driving a horizontal tunnel 900 ft. long to connect with the deep shaft connecting with the tunnel under the Hudson. It is believed that this will carry the aqueduct so far below the surface that no movement of the rock under the heavy hydrostatic pressure need be feared.

On account of the possibility of shortage in the Croton supply occurring during the next twelve months, should the drought of 1914 continue, the contract calls for pushing the work with the utmost possible speed. One year's time is the amount allowed for the work. However, in case an emergency should arise during the construction of the tunnel compelling the putting into use of the Catskill aqueduct, it would be possible temporarily to cease the work on the new tunnel and shaft and use the aqueduct as now completed, the contractor of course being obliged to suspend his work until the emergency was over and the tunnel could again be pumped out.

Readers desiring a further description of the work previously done at the Hudson River crossing may refer to the extended article on this work by Alfred D. Flinn, Deputy Chief Engineer of the Board of Water Supply, published in our issue of Mar. 23, 1911.

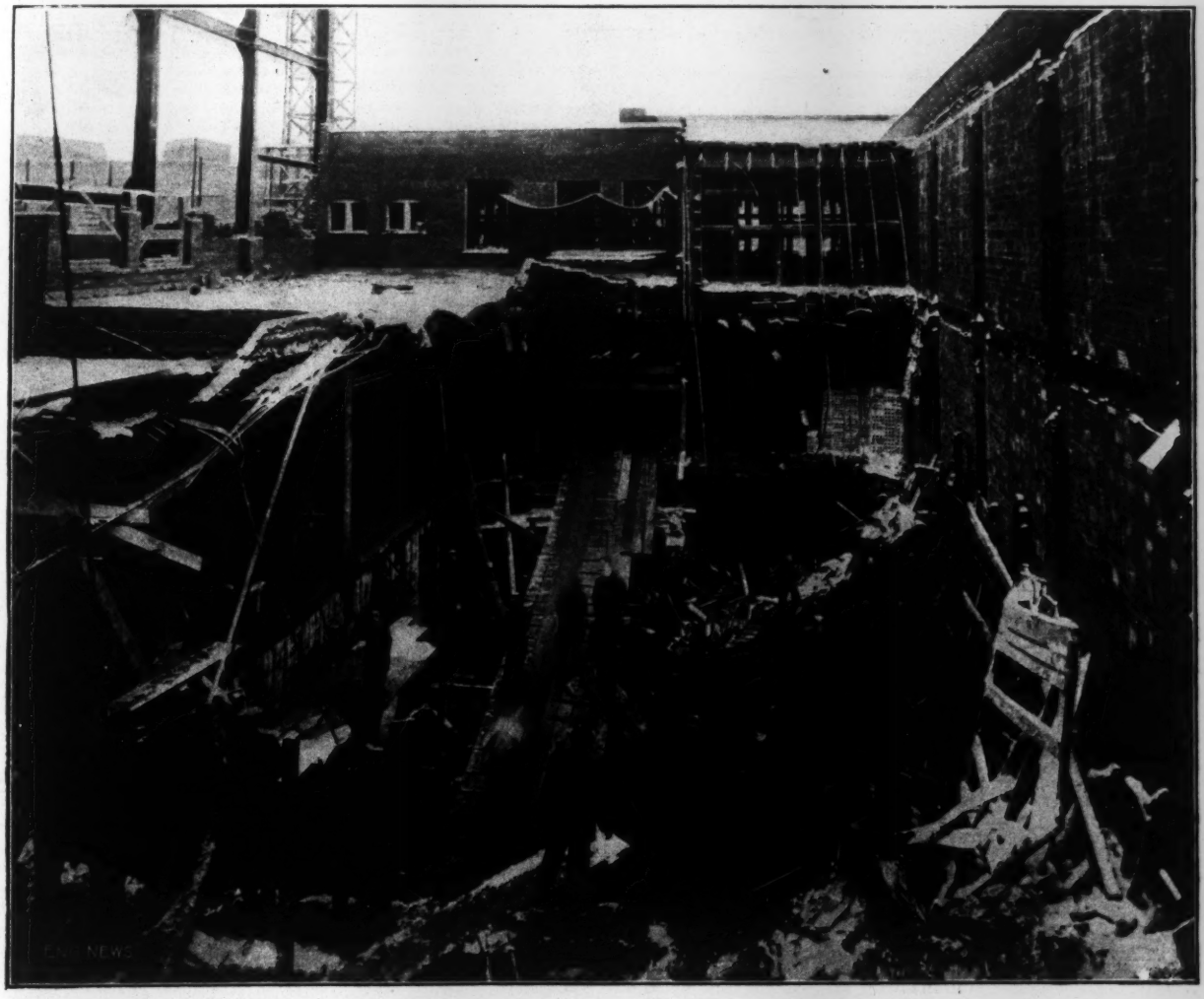
Collapse of Reinforced-Concrete Arcade, Hippodrome Building, Youngstown, O.

A section of a new arcade being built in connection with the new Hippodrome building, to run from Federal to Commerce St., in Youngstown, Ohio, collapsed during construction on Oct. 26, and killed three of the workmen who were in the lower part of the building, and injured three more. Fortunately, a great number of workmen had left the collapsed area just previous to the failure, so a much greater disaster was averted.

The building comprises a theater section of steel construction, with an adjoining arcade building entirely of reinforced concrete. This arcade had a basement and was partly one and partly two other stories in height but at the area of failure had two floors and the roof. It is of straight column-and-beam construction with columns spaced 20 ft. along the narrow dimension of the arcade and 15 ft. 3 in. along the long dimension. The collapsed portion comprised the whole three stories, throughout an area of 40 ft. wide and 107 ft. long, that is, two transverse panels and six longitudinal panels. The columns were square in section, 16x16 for the interior and 14x14 for the outside. They were reinforced with straight rods at the corners. The beams, 20 ft. in span, were 13x16 in. section, reinforced according to the Kahn system. The floors were of rib construction, according to the "Floretyle" system of the Trussed Concrete Steel Co. The floors were designed for 125 lb. per sq.ft. load.

The basement columns were cast on Sept. 22, the first-floor slab Sept. 23, the second-floor slab Oct. 2, and the roof Oct. 24; thus at the time of collapse the age of the concrete varied from two days for the roof to 34 days for the basement columns, with at least 24 days age for all the concrete below the second floor. During the time since this concrete has been laid no particularly cold weather had been experienced.

The precise nature of the collapse has not as yet been brought out. Reports have been circulated that the struts supporting the first floor were removed just prior to the accident, to allow some plumbers to get into the building with their work, but these reports have been strenuously denied by all those concerned with the building. Eye witnesses are few, so it has not yet been brought out whether the first floor failed first and carried down with it the upper portion of the building, or whether the roof collapsed



COLLAPSED PORTION OF REINFORCED-CONCRETE ARCADE, HIPPODROME BUILDING, YOUNGSTOWN, OHIO

first and its impact broke down the lower floors. As the accompanying view shows, the collapse was complete. The girders sheared off straight at the columns and at the walls and the columns, with one exception, were thrown completely down. The stump of one column still stands.

The cement was all tested by a recognized laboratory and passed the regular standard specifications. The sand and gravel were tested by the city building inspector. It is stated that the loam in the aggregate did not exceed 4%. The concrete seems to be all right.

The building was owned by the Youngstown Hippodrome Co. and was designed by Knox & Elliott, architects, of Cleveland. The contractor is the George A. Fuller Co.

NEWS NOTES

A Large Dry Kiln Collapsed at the mills of the Alabama Lumber & Kiln Co., Samson, Ala., Oct. 27. Four men were killed and 50 severely injured.

A Water Front Fire at San Pedro, Calif., on the morning of Oct. 25, destroyed the wharves and warehouses of the Crescent Wharf & Warehouse Co., the East San Pedro Cannery, and the depot of the Salt Lake, Los Angeles & San Pedro Ry.

The Falling of a Terra-Cotta Cornice on the new building under erection in Jamaica, N. Y., for a substation of the New York & Queens Electric Light & Power Co., Oct. 26, caused the death of three workmen and injuries to about twelve others.

A Section of 6-Ft. Brick Storm Sewer Collapsed, Oct. 1, at Freeport, Ill. The collapse is laid to a want of lateral support caused by excavating for a near-by building. The contractor for the building excavation has been held responsible and will make the necessary repairs.

A Disastrous Mine Explosion occurred Oct. 28 at the mine of the Franklin Coal & Coke Co., Royalton, Ill., in which about 51 men lost their lives. The explosion is reported to have been due to gas ignited by a miners' lamp. The explosion was followed by a fire and apparently by a second explosion.

Exhibition of Street Cleaning Apparatus—The exhibition to be held in New York City under the auspices of the Street Cleaning Department has been again postponed to Nov. 23-28. The exhibition will be held in the Armory of the First Regiment of Field Artillery, Broadway and 68th St. J. T. Fetherston is Commissioner of Street Cleaning.

Another Big Pier Fire, Brooklyn, N. Y.—A new 1200-ft. steel-shed pier of the Sipula-American Line, at the foot of Pacific St., Brooklyn, N. Y., was badly damaged by a fire of unknow norigin, on Nov. 4. Damage to structure and contents is estimated at $500,000. Quantities of inflammable freight stored on the pier made the fire burn fiercely.

A Fast Train Was Derailed on the Chesapeake & Ohio Ry., Oct. 28, at Barboursville, W. Va. The train broke in two and the engine, tender, baggage car and coach ran ahead some distance without suffering any damage. Three Pullman cars following were derailed by the breaking of one of the car wheels. Eighteen passengers were more or less seriously injured when the derailed cars rolled down an embankment.

Three Fires In or Near Reinforced-Concrete Buildings, which demonstrated the fire-resisting qualities of a well built reinforced-concrete structure, have been reported to us by the Trussed Concrete Steel Co., Detroit, Mich., whose systems of construction were used in each of the buildings.

In August of this year a brick building with interior wooden construction caught fire in the tannery plant of Davis & Sons, Kingston, Ont. Adjoining the brick building was a reinforced-concrete structure. The fire completely demolished the brick building, while the reinforced-concrete building was practically uninjured, although the heat was so great that the wire-glass in this building melted and the wooden water tank on its top was entirely burned. An adjoining leach house, which had concrete walls and a wooden roof, was gutted, but the concrete walls remained.

On June 27, 1914, a fire broke out in the sixth floor of the warehouse of J. R. Thomas & Sons, Youngstown, Ohio. The cause of the fire is believed to have been an explosion of rat poisoning, which simultaneously started the fire on the second, fifth and sixth floors. The explosion was of such violence as to blow out a brick wall on the south side of the building on the upper two floors, though no damage was done to the structural part of the building. The fire on the sixth floor started where two carloads of matches were stored. These naturally burned intensely, the fire keeping up for about three hours at a temperature estimated at 1700° F. The roof above the floor was of the tile and concrete beam system. The bottoms of some of the tile were destroyed but the roof remained intact. On a part of the second floor brooms and paper bags were stored to the height of the ceiling, the floor above being loaded with canned goods weighing about 300 lb. per sq.ft. This floor was not seriously damaged by the fire nor did it show any deflection. The damage to the stock amounted to about $200,000, but the building was repaired at very little expense.

On May 16, 1914, a severe fire occurred in the First Christian Church annex, Kansas City, Mo. The first and second floors of the annex were of reinforced concrete. The upper three floors were cast-iron columns, steel beams and wood joist. The building was in course of construction at the time of the fire. The upper three floors of the annex and the church itself were destroyed by the fire, but the concrete part of the building was not seriously damaged. The architects state that after a thorough examination they note that "the reinforced-concrete slabs and columns in the new addition had come through without a scar."

Stone Production in the United States broke all records in 1913, reaching a total value of $83,732,995, according to E. F. Burchard, of the U. S. Geological Survey. These figures show an increase of 7% over the value of the output for 1912, which in its turn broke all records of preceding years. Of the different kinds of stone produced, the largest increase in value was shown by trap rock, which was 23% greater than in 1912.

Some of the Old Wooden Sewers in Boston, which were described in "Engineering News," of Sept. 10, 1914, will be replaced by modern sewers during the coming winter. The work will be done in the vicinity of the post office and will be undertaken this winter not only because of the need of reconstruction but also to afford work to some of the unemployed. It is estimated that work to the value of about $150,000 will be done.

The First Subway in New York City was ten years old on Oct. 27, 1914. The first section of it to be placed in operation was formally opened on Oct. 27, 1904, when the then Mayor, George B. McClellan, opened the throttle on the first of three special trains carrying city and company officials and their guests. From the date of this opening to the close of the last fiscal year, June 30, 1914, the subway has carried 2,332,401,305 passengers, an average of more than 233,000,000 passengers per annum. (The present week-day number is approximately one million.) The total operating revenue for the same period was $120,084,198, and the operating expenses and taxes $49,549,845. The rental paid to the City amounted to $20,421,069.

The New Central Station at Memphis, Tenn., was opened for traffic in October. It is owned by the Illinois Central R.R., and is used also by the Rock Island Lines, the St Louis & San Francisco Ry. and the Yazoo & Mississippi Ry. There are five through tracks and five stub tracks, the latter being mainly for the three last-named roads, whose trains do not run north of Memphis. The station building has eight stories, the passenger facilities being mainly on the second or track floor, and the five upper floors being for railway offices. The track elevation work in connection with the new station eliminates six street crossings, and the tracks are carried over the streets by concrete-slab deck spans resting on concrete bents and abutments. The station has a present traffic of nearly 50 trains daily. The design and construction of the entire work was under the direction of A. S. Baldwin, Chief Engineer of the Illinois Central R.R. The station and other improvements were described and illustrated in "Engineering News," Sept. 24, 1914.

The Smallest Central Electric Station in the country is probably that at Clayton, Wis. The town has a population of 220, and the Clayton Electric Co. has for generating equipment one 12-hp. gas engine belted to a 5-kw. direct-current unit. The commercial service is rendered from dark to 11 p.m.; there are eight incandescent street lamps. The operating force comprises only one man.

The Covering of Jones' Falls in Baltimore, Md., was officially completed on Oct. 29, when Mayor Preston set off the blast which broke down a barrier and diverted the water from the old stream bed into the 29-ft. tunnel and thence into the covered way. The work of covering was described in "Engineering News," July 3, 1913, p. 2. Jones' Falls, an open creek running through the heart of Baltimore, for years took

street and house drainage and constituted a nuisance to sight and smell. As a part of the new sewer system of the city; now fast approaching completion, the creek was covered from its mouth near the river to near Biddle St., a distance of 5300 ft., with a three-way box conduit of reinforced concrete. From Biddle St. to Mt. Royal Ave. the stream was diverted through a 29-ft. tunnel which takes the stream from the old bed and connects down-stream with the conduit. The covering, together with a reinforced concrete viaduct at the upper end, form a low-grade street connecting the railway stations and wharves, which before had been connected by high-grade streets only.

The work was under the direction of Calvin W. Hendrick, Chief Engineer of the Sewerage Commission.

The New Water-Intake Tunnel at Milwaukee, Wis., had been driven 3017 ft. on Oct. 30, while the total length is 4000 ft. to the new crib, which has already been sunk in place. Following the cave-in and entrance of water described in our issue of Oct. 29, the grade has been lowered slightly to keep the work in solid shale rock. After the accident, it was suggested that the air lock (near the shore shaft) should be replaced by one nearer the heading, but on investigation this was considered unnecessary. A bulkhead was built, however, at about 2950 ft. from the shaft. Air pressure was used only for a short time, and the work is again progressing with the air lock out of service. The work for 1915 will include the land tunnel running southwest from the new shore shaft to the present pumping station, so that, in case of necessity, water can be taken by the new crib and intake tunnel. The intention, however, is not to utilize the new intake tunnel until the pipe lines have been laid from the crib into water about 60 ft. deep. In 1916, work will be commenced on a shore tunnel running due west from the intake tunnel to a new pumping station near the river. The new intake tunnel and its connections were described in "Engineering News," June 18, 1914.

An Injunction Against the Pollution of the Delaware River by the sewage of Phillipsburg, N. J., must be issued, according to a decision recently made by the Chancery Court in the State Board of Health vs. Phillipsburg. The major part of the decision, which is lengthy, disposes of the contentions of the defendants that (1) the power over sewage disposal originally vested in the old State Sewerage Commission was not legally transferred to the State Board of Health, a few years ago; and (2) that the power mentioned did not extend to the potable waters of the Delaware River. The court also declared that "it is idle for the defendant to ask of what avail it would be to stop" it from discharging sewage into the Delaware when Easton, directly opposite, is polluting the river. In addition, the court held, in effect, that threatened pollution would be sufficient cause for the injunction, even though actual pollution could not be proved. The injunction will carry it with the necessity for sewage disposal by Phillipsburg in a manner to be approved by the State Board of Health. An appeal to the Court of Errors and Appeals is expected. We are indebted to R. B. Fitz Randolph, Chief of the Division of Food, Drugs, Sewerage and Water of the State Board of Health of New Jersey, for a copy of the decision.

A Practical Demonstration of Fireproof Residence Construction was given by Edward F. Croker, former Chief of the New York City Fire Department, now President of the Croker Fireproof Construction Co., New York City, at his home at Long Beach, Long Island, N. Y., Oct. 30. The house is constructed of hollow tile and stucco, with steel-frame floors and partitions, metal window sashes and wire-glass windows, steel doors and trim and asbestos-plastered walls. The floors are of a material known as "konpolite." The ceilings, like the walls, are hollow tile covered with asbestos plaster. The demonstration consisted in settling a fire in one of the sleeping rooms, full of furniture and furnishings, helped out by two gallons of gasoline, shutting the door and allowing the fire to burn itself out. No damage was done the house or the walls of the room. As guests of the occasion Mr. Croker had many fire prevention engineers and experts and an illustrated report is to be made. Mr. Croker claims this is the first and only actual fireproof residence in this country. His object, which seems to have been fully accomplished, is stated as follows:

> My experience, both as a fireman in the ranks and as a Chief of the Fire Department of the City of New York, covering a period of 27 years, convinced me it was both possible and feasible for the average owner of residences, both private and apartment houses (and particularly large residences in the suburban districts), to construct at very little additional expense, if any, an absolutely fireproof home in every sense of the word; in fact, a residence whereby shutting the door of each room at night, one could feel safe that, even if a fire did occur, it would be confined to the room in which it originated, permitting the occupants of the other rooms to sleep in absolute security.

PERSONALS

Mr. T. R. Quay has resigned as Heating and Ventilating Engineer of the city building inspection department of Cleveland, Ohio.

Mr. Thane R. Brown, Assoc. Am. Soc. C. E., for 20 years with the Wisconsin Bridge & Iron Co., Milwaukee, Wis., has been promoted to be Chief Draftsman.

Col. John Biddle, M. Am. Soc. C. E., Corps of Engineers, U. S. A., has been detailed as a military observer with the Austrian Army. He has been on temporary duty with the Chief of Engineers at Washington, D. C.

Mr. W. J. Dyer, M. Am. Soc. M. E., Assistant Manager of the Honolulu Iron Works Co., Honolulu, H. I., has resigned to engage in private practice, with offices in the Stagenwald Bldg., Honolulu.

Mr. J. M. Keller, M. Am. Soc. M. E., until recently Chief Engineer of the Otis Steel Co., Cleveland, Ohio, has been appointed to the newly created position of Chief Engineer of the National Carbon Co., also of Cleveland.

Mr. John R. Haswell, Jun. Am. Soc. C. E., Drainage Engineer, United States Department of Agriculture, has been transferred to Baltimore, Md., to represent the drainage division [illegible] Delaware, New Jersey, Pennsylvania and New York.

Mr. F. C. Herrmann, M. Am. Soc. C. E., Chief Engineer of the Spring Valley Water Co., San Francisco, Calif., has resigned to engage in private practice as a Consulting Engineer, specializing in hydraulic engineering, with offices in the Merchant's Exchange Bldg., San Francisco.

Mr. William T. Dougan, M. Am. Soc. C. E., Engineer of Maintenance-of-way of the New York Rys., resigned Oct. 1 to engage in private practice. He graduated from Union College in 1892 and his first experience was as Assistant to the Chief Engineer on the construction of the Fonda, Johnstown & Gloversville R.R. Later he was Chief Engineer on construction of the Herkimer, Mohawk, Ilion & Frankfort Electric R.R. He entered the service of the Metropolitan Street Ry., New York City, in 1897.

Mr. Hugh C. Mitchell, recently Engineer in charge of the Topographic Survey of Cincinnati, Ohio, which was described in "Engineering News," Apr. 3, 1913, has become associated with the firm of Brown & Clarkson, Topographic Engineers, Star Building, Washington, D. C. Mr. Mitchell was for many years an officer of the United States Coast & Geodetic Survey and in coöperation with the firm of Brown & Clarkson will specialize in geodetic survey work and engineering topographic surveys of cities, borough, counties and large land divisions.

Mr. Joseph A. Kitts, Assoc. M. Am. Soc. C. E., has resigned from the service of the Panama Canal and returned to the United States. Mr. Kitts entered the service of the Isthmian Canal Commission, in 1905, when a student on leave of absence from the University of California. He was successively with the engineering staffs of the Bureau of Machinery and Equipment, the Panama R.R. and the Municipal Department. Returning to San Francisco after the fire of 1906 he was engaged on reconstruction work. After completing his studies at University of California, he was reappointed to the Canal Service in 1910, and has been engaged as Principal Assistant in charge of surveys for the construction of the Toro Point Breakwater; Engineer in charge of surveys for the excavation of Mindi cut, installation of machinery, lock gates, towing and return railways, Gatun locks, and construction of the Pacific terminal shops.

Mr. Frank M. Williams, M. Am. Soc. C. E., former State Engineer of New York, has been again elected State Engineer on the Republican ticket, defeating the Democratic nominee. Mr. John A. Bensel, Past-President, Am. Soc. C. E., the present State Engineer. Mr. Williams was born in 1873 and graduated from Colgate University in 1895, and in 1897 from the law department of Syracuse University. He was for a time City Engineer of Oneida, N. Y., and in 1900 became connected with the State Engineer's department of New York, where he was successively promoted until he reached the rank of Resident Engineer of the Barge Canal. He was elected State Engineer in 1908, and served one term of two years. Afterward he was Chief Engineer of the Coleman du Pont Road project in Delaware, and for the past year or two, until recently, he was Chief Engineer of the Portage County Improvement Association in Ravenna, Ohio, where he had charge of the improvement of 900 miles of roads.

OBITUARY

John Z. Lott, President of the Flatbush Water Co., Brooklyn, N. Y., died Oct. 24.

David P. Canavan, senior member of the firm of Canavan Bros. Co., Contractors, New York City, died Sept. 21. He was 47 years old.

James Steel, a civil engineer with the Pennsylvania State Highway Department, committed suicide at his home in Carlisle, Penn., Oct. 24.

Mark B. Crist, a member of the engineering staff of the Westinghouse Machine Co., Pittsburgh, Penn., died at his home in that city, Oct. 26, aged 43 years. He graduated from Purdue University in 1896.

Theodore de Joly de Sabla, a director of the old Panama R.R. Co. and associated with Ferdinand de Lesseps in the attempt to build the Panama Canal during the eighties, died Oct. 29, at his home in Plattekill, N. Y.

Brayton Ives, former President of the Northern Pacific Ry., died Oct. 22, at his summer home in Ossining, N. Y. He was born at Farmington, Conn., in 1840 and graduated from Yale University in 1861. He served in the Union Army during the Civil War. He was President of the Northern Pacific Ry. from 1893 to 1896, but was chiefly noted as a financier.

Edward F. Winslow, former President of the St. Louis & San Francisco R.R., died Oct. 22, at his home in Canandaigua, N. Y. He was born in Maine in 1837. During the Civil War he served as an officer in the Union Army. Following the war he engaged in business as a railway contractor and as such, built the St. Louis, Vandalia & Terre Haute R.R., now a part of the Vandalia R.R. He was President of the St. Louis & Southeastern R.R. during the construction period and was also a contractor for the construction of other lines in the Middle West. He was Receiver, Vice-President and General Manager of the Burlington, Cedar Rapids & Northern R.R. and subsequently Vice-President of the Atlantic & Pacific R.R., now a part of the Santa Fé System. Later he was Vice-President of the Manhattan Elevated Rys. in New York City. He was elected President of the St. Louis & San Francisco R.R. in 1880 and the following year was also made President of the New York, Ontario & Western R.R. In addition he was President of the North River Construction Co., chief contractor for the construction of the New York, West Shore & Buffalo R.R.

ENGINEERING SOCIETIES

COMING MEETINGS

AMERICAN ROAD CONGRESS.
Nov. 9-14. Atlanta, Ga. Permanent headquarters, American Highway Association, Colorado Building, Washington, D. C.

INDUSTRIAL WELFARE AND EFFICIENCY CONFERENCE
Nov. 16-20. Conference at Harrisburg, Penn. Secy., R. M. Pennock, Harrisburg, Penn.

NATIONAL MUNICIPAL LEAGUE.
Nov. 17-21. Annual meeting at Baltimore, Md. Secy., Clinton Rogers Woodruff, North American Building, Philadelphia, Penn.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS.
Nov. 19-20. Annual meeting at Columbus, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Nov. 30-Dec. 1. Annual meeting at New York. Secy., W. H. Ross, 154 Nassau St., New York City.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Nov. 30-Dec. 5. Annual meeting at Jacksonville, Fla. Secy., Prof. Selskar M. Gunn, Massachusetts Institute of Technology, Boston, Mass.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 1-4. Annual meeting at New York City. Secy., Calvin W. Rice, 29 W. 39th St., New York City.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 2-4. Convention at Washington, D. C. Secy., D. Knickbacker Boyd, The Octagon, Washington, D. C.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 7-10. Annual meeting in New York City. Secy., Percy H. Wilson, Bellevue Court Bldg., Philadelphia, Penn.

AMERICAN MINING CONGRESS.
Dec. 7-11. Annual meeting at Phœnix, Ariz. Secy., J. F. Calibreath, Denver, Colo.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 9-12. Convention at Richmond, Va. Secy., C. A Prosser, 140 W. 42d St., New York City.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Dec. 10-11. Annual meeting at New York City. Secy., L. H. Cox, 29 W. 39th St., New York City.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Dec. 14-18. Convention at Chicago, Ill. Secy., E. L. Powers, 150 Nassau St., New York City.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 28-30. Annual meeting at Madison, Wis. Secy., F. M. White, Madison, Wis.

Society of Naval Architects and Marine Engineers—The annual meeting will be held Dec. 10 and 11 at the Engineering Societies' Building, New York City. The program includes 13 papers by prominent engineers.

Association of American Portland Cement Manufacturers—The annual meeting will be held Dec. 7-10, at the Hotel Biltmore, New York City. The Secretary is Percy H. Wilson, Bellevue Court Building, Philadelphia, Penn.

Snow Removal Conference—The Snow Removal Conference, first held in Philadelphia, Penn., last April, is to have another session Dec. 3, at the annual meeting of the American Society of Mechanical Engineers. The reports of the first conference will be read and discussed, and much new matter will be presented.

Cleveland Chapter of the American Society of Civil Engineers—The organization of this Chapter was completed on Oct. 28. A nominating committee was appointed to choose and submit to members of the American Society of Civil Engineers in northern Ohio two names each for president, vice-president and secretary-treasurer.

City Planning Convention Held in California—A convention, held under the auspices of the League of California Municipalities, took place at Santa Cruz, Calif., from Oct. 12 to 15, 1914. Its object was to discuss city planning and to develop a plan which would be applicable to city extension and new towns in that state.

American Institute of Chemical Engineers—The seventh annual meeting will be held in Philadelphia, Penn., Dec. 2-5. The program includes excursions to a number of large chemical manufacturing plants in and around the city. There will be a number of papers and addresses on "The Present Opportunities for American Chemical Industries."

Portland, Ore., Association of Members of the American Society of Civil Engineers—The association held its annual meeting Oct. 22, when the following officers were elected: President, George C. Mason, Consulting Engineer, and Second Vice-President, John T. Whistler, Engineer, U. S. Reclamation Service. The terms of the First Vice-President and Treasurer do not expire for another year.

American Society of Heating and Ventilating Engineers—The annual meeting will be held in the Engineering Societies' Building, New York City, Jan. 19-21. The following officers have been nominated: For President, Dwight D. Kimball, New York; for First Vice-President, Harry M. Hart, Chicago; for Second Vice-President, Frank T. Chapman, New York; for Treasurer, Homer Addams, New York. The Secretary is J. J. Blackmore, 29 W. 39th St., New York City.

American Road Congress—The prospects are that this congress will be a notable one both for papers and exhibits. Special trains will leave New York City and other points in the East and Middle West. The convention lasts from Nov. 9 to 14. The program includes many social events as well as technical discussions. There will be a reception at the state capitol by Governor and Mrs. Slayton, on the opening day; a tea for the ladies the second day; an organ recital the evening of the third day, and probably other events to be announced later.

American Railway, Bridge and Building Association—The 24th annual convention of this association was held in Los Angeles, Calif., Oct. 20-23. The sessions were presided over by the president of the society, J. N. Penwell.

Committee reports were presented upon Ice Houses, Bridge Warnings, Reinforced-Concrete Bridge Work, Care of Traffic while Constructing Bridges to Eliminate Grade Crossings, Water Supply and Concrete Posts, Poles and Signs. About 130 members were in attendance at the meeting, and 40 new members were admitted. The officers elected were as follows: President, L. D. Hadwen, C., M. & St. P.; Vice-Presidents, G. Aldrich, N. Y., N. H. & H., G. W. Rear, Sou. Pac., C. E. Smith, Mo. Pac., and E. B. Ashby, L. V.; Secretary, C. A. Lichty, C. & N. W.; Treasurer, F. E. Weise, C., M. & St. P. Executive committee, W. F. Steffens, N. Y. C.; S. C. Tanner, B. & O.; Lee Jutton, C. & N. W.; W. F. Strouse, B. & O.; C. R. Knowles, I. C. RR., and A. Ridgway, D. & R. G. Excursions were taken during the meeting to Redondo Beach and Ocean Park and up Mount Lowe. The next annual convention will be held at Detroit.